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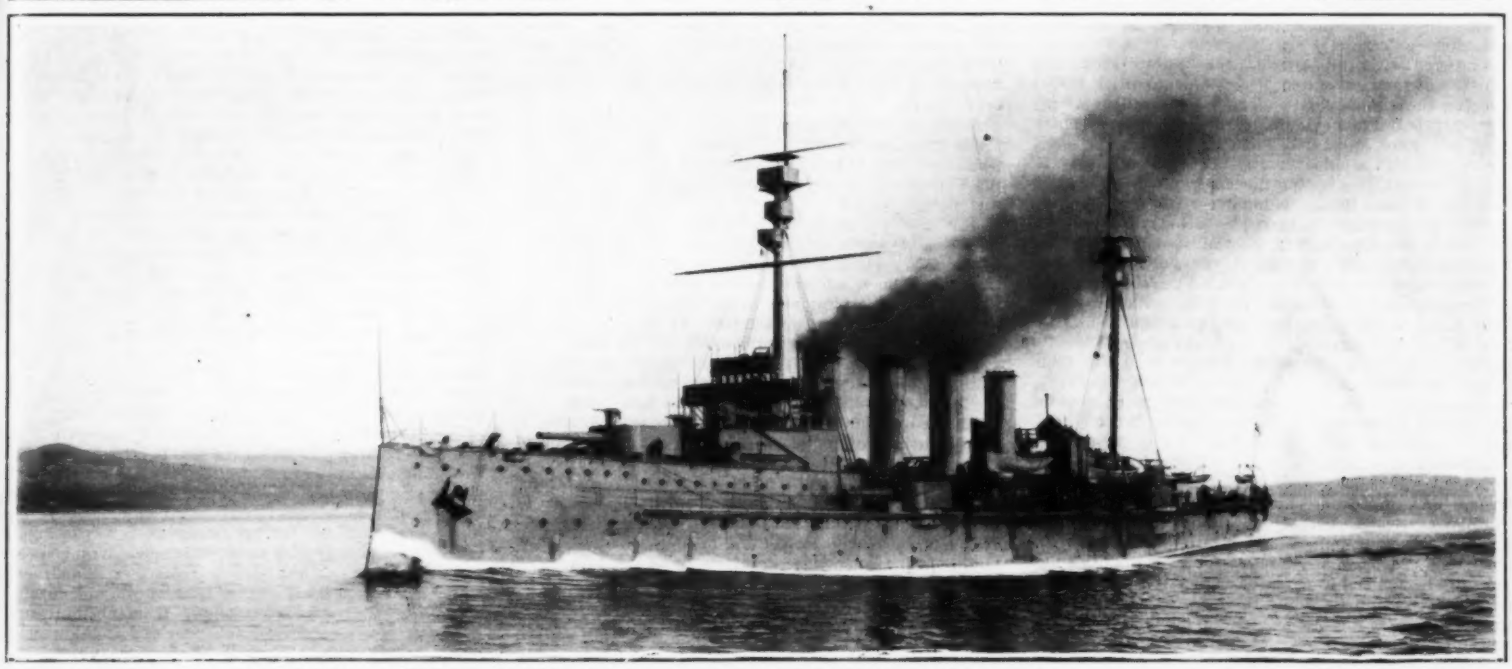
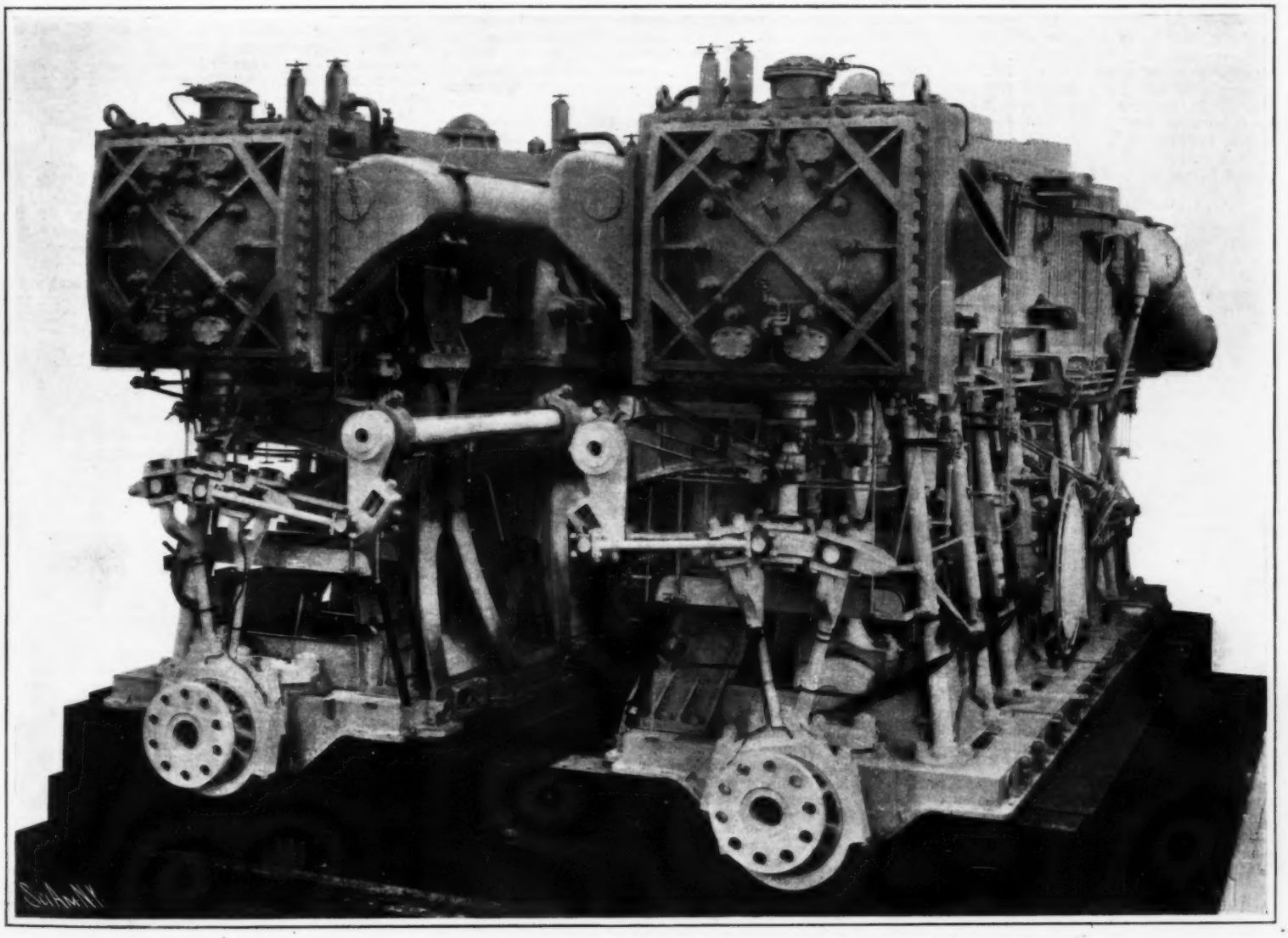


Displacement, 13,550 tons. **Speed,** 23.34 knots. **Fuel supply,** 2,000 tons coal, 400 tons oil. **Armor:** Belt, 6-inch; turrets, 6-inch; deck, ¾-inch. **Armament:** Six 50-caliber, 5 2-inch; four 50-caliber, 7.5-inch; twenty-two 3-pounder semi-automatics. **Torpedo tubes,** three submerged.

THE ARMORED CRUISER "NATAL" ON HER TRIAL TRIP.



Indicated horse-power, 23,562. **Revolutions per minute,** 197. **Coal consumption:** Main and auxiliaries, 1.8 pounds.

THE TWIN FOUR-CYLINDER, TRIPLE-EXPANSION ENGINES OF THE "NATAL."

THE NEW BRITISH CRUISER "NATAL."*

THE new British cruiser "Natal," which has recently undergone her trials, is one of a class of four sister ships of 13,550 tons displacement. She corresponds in type to our own armored cruisers of the "California" class, with which the "Natal" will be compared in the particulars which are herewith given. The "Natal" is 480 feet long, 73½ feet broad, and has a maximum draft of 27½ feet. She is an improvement upon the "Drake" class of armored cruisers, and the "Drake" will be familiar to those of our readers who had an opportunity to inspect her, during the visit of the Atlantic fleet to American waters about twelve months ago. Like the "Drake," she is a two-masted, four-funneled ship, with a lofty forecastle deck upon which the forward 9.2-inch rifle is mounted. Her armament, however, is distinctly different from that of the "Drake," which consisted of two 45-caliber 9.2-inch guns, one forward and one aft, in barbette turrets, and sixteen 45-caliber 6-inch guns, disposed in as many casemates.

Compared with the "Drake," the "Natal" shows the influence of the new system of armament, which favors reducing the number and increasing the caliber of the guns, her battery consisting of six 50-caliber 9.2-inch guns and four 50-caliber 7.5-inch. The larger guns are mounted in single turrets, one forward, one aft, and one at each corner of the central redoubt. Each of the four guns in the redoubt can be trained from 45 degrees forward or abaft the beam to a bearing dead ahead or dead astern, as the case may be. On either beam, between the 9.2-inch guns, are two 7.5-inch guns mounted in single turrets. The concentration of heavy gun fire obtained by this arrangement is three 9.2's ahead and astern, and four 9.2's and two 7.5's on either beam. All of the guns are of the new pattern and of great penetrating power for their weight. The 9.2 fires a 380-pound shell, with a velocity of 2,800 feet per second, which is capable of penetrating 13 inches of Krupp steel at 3,000 yards, and 10 inches at 5,000 yards. The 7.5 gun fires a 200-pound shell at the same velocity, with a penetration of 9¼ inches at 3,000 yards, and 6½ inches at 5,000 yards. For protection against torpedo attack, the "Natal" carries a battery of twenty-two semi-automatic 3-pounders, ten of which are grouped on the superstructure deck around the foremast, and twelve upon the same deck around the mainmast. These guns are altogether too light for their work; the 3-inch is none too heavy, and the Japanese are using the 4.7-inch for torpedo defense. She also carries three 18-inch submerged torpedo tubes.

The armor is distributed on the customary armored cruiser plan, and consists of a continuous belt 6 inches thick amidships and tapering to 4 inches at the bow and 3 inches at the stern. The 6-inch portion of the belt extends for 300 feet of the vessel's mid-length, and it is carried up to the upper deck with transverse bulkheads connecting the ends of it, thus forming a central redoubt of armor, everywhere 6 inches in thickness. Behind this protection the shallow barbettes and ammunition tubes of the 9.2 and 7.5 guns extend down to the ¾-inch protective deck, which slopes at the sides to a junction with the lower edge of the waterline belt. All of the main guns are mounted in turrets protected by 6 inches of Krupp steel.

The ship is driven by two sets of four-cylinder, triple-expansion engines, of the usual naval type. Steam is supplied by nineteen Yarrow and six cylindrical boilers. The vessel can stow 2,000 tons of coal and about 400 tons of oil. Our illustrations include the engines and a view of the "Natal" on her full-speed trial. The government tests are severe. They require that the propelling machinery shall run for thirty hours at one-fifth full power; for another thirty hours at 70 per cent of full power; and for eight hours at the maximum power. Moreover, during these trials no alterations can be made in the machinery, nor is any water permitted to be used on the bearings. During the thirty hours run at 70 per cent of the full power, the "Natal" maintained a speed of 21.35 knots. On the eight-hour, full-speed trial, the engines ran at 137 revolutions per minute, and indicated 23,592 horse-power, the mean speed obtained being 23.34 knots, which, as compared with her designed speed of 22.33 knots, shows that the vessel was driven at over a knot more than her guaranteed speed.

A valuable feature in this ship is the provision for carrying a large supply of oil fuel; for when the bunkers situated near the boilers are empty, the oil fuel can be turned on and the stokers liberated for the work of removing coal from the bunkers which are more remote from the furnaces. Because of the tactical advantage thus conferred, this feature will be of great value in a naval engagement. The fuel consumption (a most important point in its effect upon the ship's radius of action) was very satisfactory; for with all of her auxiliary machinery at work, only 1.8 pounds of coal was burned per indicated horse-power. With oil fuel, the consumption will probably be about 1 pound of oil per indicated horse-power per hour. Estimated on this basis, the "Natal" can steam at the high speed of 21½ knots for a distance over 4,000 nautical miles. For our illustrations and particulars we are indebted to the builders, Messrs. Vickers, Sons & Maxim.

Antimony has a hardening effect when added to lead; a small quantity of bismuth gives the alloy the property of expanding at the instant at which it solidifies, the result being a perfect cast from the mold.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

CHARACTERISTICS OF SOME POWER GASES AND THEIR TREATMENT.*

By L. L. BREWER.

THE importance of a thorough knowledge of both the chemical and physical properties of gases used in gas engines cannot, in the opinion of the writer, be too strongly emphasized. Neither the designer nor the operator of gas engines can afford to slight this part of his necessary knowledge; for successful operation depends in a large measure on the quality of the gas delivered to the engine.

It is needless to say that an engine designed to use gas of a certain quality is not as well adapted for gas of some other quality, but what is important is that a gas of any chemical quality must also be of good physical quality, or, to put it briefly, it must be clean. The importance of having it clean is great. Dust forms the largest part of the foreign matter that it is necessary to remove, and apparatus designed to remove this dust is equally applicable to all kinds of gas. Hence, while such apparatus is discussed only in connection with blast-furnace gas, which carries the greater amount of dust, the discussion relates just as well to other gases.

Attention is also called to the fact that reference is made more particularly to European practice and experience. This is in a large measure necessary because the Continent has had practically all the experience in this field.

BLAST FURNACE GASES.

The waste gases of blast furnaces contain combustible portions which are a valuable source of heat, and these gases have for this reason been for a long time past carefully caught and used, instead of being permitted to burn at the furnace top. At the head of these combustibles stands carbonic oxide (CO), which constitutes about one-quarter of the entire gas volume, and contains over nine-tenths of the total heat value of the same. Of the remainder of the gas, about one-tenth to one-eighth consists of carbonic acid (CO_2), about one-half of nitrogen (N), and the remainder of water in gaseous form, hydrogen (H), and, occasionally, in smaller quantities, the lighter hydrocarbons. The latter two afford the balance of the heat value of the gas.

The more nearly perfect the combustion of the fuel in the blast furnace, the greater will be the proportion of CO_2 as compared with CO, and the lower, therefore, the heat value of the waste gases. Assuming that in the production of one ton of pig iron one ton of average coke is burned, there will be delivered at the blast-furnace top about 150,000 cubic feet of gas; roughly speaking, this gas would be composed of about 25 per cent of CO and 2 per cent H, its heat value thus being about 87 British thermal units per cubic foot.

The volume of waste gas produced in a blast furnace per ton of pig output depends mainly upon the quantity of carbon fed into the furnace; in other words, upon the quantity of coke consumed per ton of pig produced. Consequently, the more economically the furnace is operated in this respect, the smaller will be the volume of the waste gas, and the lower also, as already mentioned, the heat value of the gas. Improvements in the operation of blast furnaces will, therefore, bring with them a reduction of the amount of waste heat available as a by-product. On the other hand, the demands for power, in the development of which this heat may be used, would increase in consequence of the higher blast pressure and the substitution of machinery for hand labor. The blast stove, in the heating of which about 30 to 40 per cent of the waste gas is consumed, will in future require, if anything, yet higher heating, and if it is desired to avoid the use of coal for the development of additional power required, the necessity will become more and more pressing of taking advantage of the best and most economical means available for the utilization of the heat of gases in power machines. In consideration of the high degree of perfection attained by modern steam engines and steam boilers, any further considerable improvement in this direction cannot be expected, and as the gas engine offers the possibility of more than doubling the economic efficiency of the first-class steam plants of to-day, the field will in the future belong to it.

A good average boiler plant, using waste gas for fuel, generates with 25 cubic feet of gas one pound of steam at a pressure of 150 pounds per square inch, and the average steam engines in iron works consume about 17 pounds of such steam per brake horse-power-hour. On this basis, a blast-furnace plant of 600 tons daily output will develop in steam engines 5,300 horse-power, of which 3,600 horse-power will be required for the operation of the plant, leaving a surplus of 1,700 horse-power available for other purposes. The same quantity of gas would, if used directly in gas engines, develop about 17,000 horse-power, and even allowing for the requirements of the plant the increased amount of say 4,500 horse-power, there would remain an available surplus of 12,500 horse-power.

The question is, therefore, the extent to which the waste gases are suitable for use in gas engines. Their heat value is considerably lower and their dust content very much higher than those of other gases, particularly illuminating gas, and in the beginning it was feared that the low heat value would lead to uncertainties in ignition, but in this respect the difficulties have been overcome by the knowledge, based upon experience, that with sufficiently high compression even poor gases may be ignited with certainty. The second objection is a more difficult one to overcome. It appeared at first almost impossible to remove from the gas the large quantities of dust contained in it; but, as the fact became appreciated that this dust exercised a very detrimental effect on the utilization of the heat of the gas in the blast stove and under boilers, the cleaning of the gas to at least a partial extent was found to be expedient long before attempts were made to utilize the gas in engines. Years of operation in a number of European blast-furnace plants have proved conclusively that the apparatus and attendance necessary for the partial cleaning of the gases paid for themselves in improving its heating effect in the blast stoves and reducing the frequency of their costly cleaning. The problem of still further cleaning the gas after the coarse dust has been removed in the partial or preliminary cleaners may be considered as solved, from both the technical and economic standpoints.

* Power.

CLEANING THE GAS.

The average European blast-furnace gases contain as much as 12 grains of dust per cubic foot, and if used in blast stoves and under boilers, are generally cleaned to a dust content of 2 to 2½ grains per cubic foot. This incomplete cleaning is effected partly dry and partly with water sprays, while the gas is conducted at low velocity through large, long pipes, and the direction of its flow occasionally abruptly changed; also by passing the gas over the surface of water, which retains the dust, or causing it to pass through and against sprays of water. Two such installations have been in operation over ten years. The first of these is located in Hoerde, in the works of the Hoerder Bergwerk und Huttenverein, and is on the dry principle. Its capacity is sufficient for a blast furnace producing 200 tons of pig per day, or for about 25,000 cubic feet of gas per minute, which gas is cleaned therein to a dust content of 2 to 2½ grains per cubic foot. The second is the works of the Georgs-Marien Bergwerk u. Huttenverein, near Osnabrück, and is on the wet system, cleaning 12,000 cubic feet of gas per minute to a dust content of 1.3 grains per cubic foot. After passing through this latter apparatus the gas carries about 3 per cent by weight of water vapor.

The above mentioned methods, while efficient enough for the cleaning of the gases for use in blast stoves and under boilers, do not reduce the dust content sufficiently for the direct use of the gases in engines. The volume of gas intended for use in engines is, therefore, subjected to further cleaning by passing it through vertical scrubbers in which are arranged, one above another, a number of tables or diaphragms which are sprayed with water from above, and through which the gas passes from below. The substance used upon the tables is immaterial, provided it induces the best possible contact between the water and the gas. Coke layers, fine wooden lattices, or perforated plates are used with about equal success.

In order to reduce still further the dust content of the gas to the desired degree, sawdust scrubbers are used, in which the gas passes through a number of layers of dry sawdust. These dry scrubbers effect excellently the reduction of both the dust content and the humidity of the gases; but they require considerable floor space and much labor in the renewal of the sawdust. A typical installation on these lines is that in the Friedenshutte in Upper Silesia. In this the dust content of the gas is reduced to a trace (0.001 grain per cubic foot) and the moisture to about 1 per cent by weight. The installation has a capacity sufficient for about 8,000 cubic feet of gas per minute.

The many obstructions opposed to the passage of the gas during the process of cleaning rapidly absorb the low pressure under which the gas is discharged at the furnace top. In consequence of this, the gas pressure must practically without exception be increased by artificial means. The Friedenshutte is probably the only installation which is operated without such artificial means, and this is simply because in this plant there is cleaned at the present time only about one-quarter of the volume of gas for which it was intended, so that the resistances in the conduits and cleaners are exceedingly low. Generally the gas must be driven forward mechanically, and for this purpose a steam injector or fan is used. Both of these appliances were originally installed merely with the intention of maintaining the gas pressure; but both soon proved that besides performing this function they exercised a considerable cleaning effect. At present, steam is always available in blast-furnace plants and this will probably be the case for a considerable time to come; consequently, there is no difficulty in the introduction of a steam injector in the gas main, and such injector may often be operated in connection with the scrubbers already described. The cleaning effect of the injector results mainly from the fact that the steam moistens the dust particles and causes these to form larger agglomerations which are deposited when the steam is subsequently condensed. The steam consumption of injectors is somewhat high; should economy in this respect become expedient, however, the steam may be generated practically without cost by heating the circulating water from the gas engines by means of the exhaust.

The steam injector has never caused any trouble, but the centrifugal fans first installed became rapidly choked by the dirt so that it was necessary to stop and clean them frequently. This led to the use of water injected into the fan casing, and by this means not only was the foregoing difficulty overcome, but a very thorough cleaning of the gas was effected by the dust being thrown out toward the circumference by centrifugal force and being there taken up by the water. By this process the problem of cleaning the waste gases is solved in a simple and inexpensive manner, and the fan is, consequently, in general use for this purpose. Sometimes it is used in conjunction with washers and scrubbers, but frequently it is the

soie cleaning apparatus in addition to the ordinary dust catchers. With this latter arrangement the effect of a single fan is not sufficient and therefore a number of fans are worked in series. One of the first installations of fans in series, and one which makes the utmost use of these machines, applying them also for the preliminary cleaning, is located in Kneuttingen, in the iron works of the Lothringische Hochofengeseilschaft, Aumetz-Freide. This plant subjects about 5,000 cubic feet of gas per minute to preliminary cleaning and about 2,800 cubic feet of gas per minute to more thorough cleaning for direct use in engines, in the latter operation reducing the dust content to 0.04 grain per cubic foot.

Steam injectors, as well as fans, consume power, and this in proportion to the dust content of the gases. The power absorbed by the injectors varies between 4 and 8 per cent, and in fans between 2 and 6 per cent of the power which the volume of gas handled would produce if used directly in gas engines. This is a minor consideration as compared with the resulting advantages; but this method of cleaning requires a large quantity of water, which is not always available. The water consumption per 1,000 cubic feet of gas amounts in wet preliminary cleaners to about 75 gallons, and in coke scrubbers to about 15 gallons, while each fan performing the final cleaning consumes about 6 gallons per 1,000 cubic feet of gas.

With the view of reducing the power and water consumption, it was deemed feasible to construct modified centrifugal fans in which the water is conducted in the direction contrary to the flow of gas, on the counter-current principle, and spirally along the walls of the fan casing, so that the coldest and cleanest water will come in contact with the cleanest gas, and the heated and dirty water with the dirty gas. A centrifugal gas cleaner on this system, although of imperfect design, was first invented and patented by Windhausen in 1883, and later on in a quite different form by Eduard Theisen. Such a centrifugal cleaner combines in itself all the functions of throwing out dust, washing, evaporating, condensing, and drying, and those who have tested this apparatus in practice are unanimous in the opinion that when it works at all, its performance is excellent, while its consumption of power and water is very low; but all of the earlier installations were of such bad design and poor workmanship that it was impossible to maintain them in operation. Theisen apparatus installed in Gelsenkirchen in the works of Schalker Gruben und Huttenverein appears to be of better construction, and according to the statement of the inventor, a machine lately installed in the Ilsederhutte has gained the entire approval of the purchasers. At the present time, Theisen lays claim in his patent specifications not only to this special apparatus, but also to the idea of using fans with water injection; but in view of the already expired patent of Windhausen, it would appear impossible to uphold any such claim. It is stated in a published report of the works management that the Theisen apparatus installed in Schalke will clean 4,000 cubic feet of gas per minute to a dust content of 0.001 grain per cubic foot; and in doing so, consume 30 gallons of water and about 60 horse-power.

Should circumstances render it necessary to use the water for cleaning purposes over again, it must be purified in settling tanks or reservoirs. The requisite capacity of such tanks varies with the quantity and character of the dust, and with the degree of thoroughness with which the water is used, to such an extent that it would be impossible to lay down any definite general figures.

In smaller works, where but a few blast furnaces are in operation, it would be expedient to install a gas holder for storing the cleaned gas, in order to counterbalance occasional irregularities in the operation of the furnace. The larger the number of furnaces, the smaller may such holder be; and, in fact, many iron works with three and more furnaces do not use such a gas holder at all.

COKE-OVEN GASES.

In the coking of coal, gases are generated, having an average composition about as follows: 50 per cent hydrogen (H); 30 per cent hydrocarbon; 8 per cent carbonic oxide (CO); and the balance nitrogen (N) and carbon dioxide (CO_2). In coking one long ton of coal, there are generated about 10,000 cubic feet of such gas, having a heat value of 350 to 600 British thermal units per cubic foot. This gas is, however, not suitable for direct use in gas engines or under boilers, because of its high content of hydrocarbons, as these, in consequence of the resulting deposition of chemical impurities, would rapidly lead to the fouling and interruption of the system. These chemical impurities may be extracted and turned into the by-products, tar, ammonia and naphtha, in the proportion of about 80 pounds of tar, 15 pounds ammonia, and 11 pounds naphtha per long ton of coal coked. As these by-products command good prices, they will usually pay for their extraction, and this process is therefore generally employed.

In saving the by-products, the gas is very effectively cleaned, so that only a small amount of moisture and occasionally a certain amount of sulphureted hydrogen (H_2S) remain. In order to remove these, the gas is generally forced through a dry scrubber having three tables or diaphragms, the first of these carrying a layer of clayey iron ore which absorbs the sulphureted hydrogen, and the remaining two tables carrying layers of sawdust, which serve to dry the gas. Of the entire volume of cleaned gas, about two-thirds is required to heat the coke ovens and carry on the coking process. It may be stated, in passing, that the proportion of coke yielded by a given weight of coal varies between wide limits (40 to 90 per cent), the average in Germany being about 85 per cent.

A coke-oven plant having an output of 600 tons of coke per day would, assuming a yield of 85 per cent of coke, leave available for direct use in gas engines sufficient gas to develop 3,500 brake horse-power. The operation of the coke plant absorbs about 600 brake horse-power, leaving available for other purposes about 2,900 brake horse power. Comparing this statement with the earlier computation showing that, in a blast-furnace plant of 600 tons output using blast-furnace gases directly in gas engines, the available surplus power amounts to 12,500 horse-power, it will be noted that where a coke plant is in operation in direct connection with a blast-furnace plant, and the surplus coke-oven gases as well as the surplus blast-furnace gases are used directly in gas engines, this arrangement of plants would increase the available surplus of power about 30 per cent above what it would be were the coke-oven gases not so utilized.

These facts clearly indicate that the use of coke-oven gases as a source of power can be made very profitable, assuming that the coke plants are arranged for the saving of the by-products, the final cleaning of the gases being in such case very much simpler than it is for blast-furnace gases, and the rich coke-oven gases being excellently adapted for use in gas engines. If the by-products were not saved, the chemical cleaning of the gases would become too complicated, and any attempt to use the gases after being merely cleansed from dust would in a very short time cause a stoppage of operation. The importance of proper cleaning is therefore obvious.

PRODUCER GAS.

The economy of generating producer gas from coal and coke and using such gas in gas engines has long been appreciated, and many efficient gas producers have been developed. A gas which would be produced by the simple gasification of the coke or coal with air to generate carbonic oxide (CO) would be of very low heat value (about 75 British thermal units per cubic foot), and such gas is therefore enriched by blowing steam through the incandescent coke or coal. This steam is decomposed, forming hydrogen (H) and increasing the heat value of the producer gas to about 130 British thermal units per cubic foot. One pound of coke containing 87 per cent carbon will generate in the producer about 75 cubic feet of gas consisting of 27 per cent carbonic oxide (CO), 7 per cent hydrogen (H) and 2 per cent hydrocarbons.

The best fuel for generating gas in a producer is anthracite coal or anthracite mixed with gas coke. The former alone has a tendency to clog the producer, and entails more frequent cleaning of grates in consequence of its larger percentage of ash. Successful attempts have been made to generate gas from bituminous coal in a gas producer, the gas so produced being naturally of same constituency as that generated in coke ovens in the coking of bituminous coal. Impurities (chemical by-products) must in some way be eliminated before the gas can be used in gas engines, and in addition to this, proper steps must be taken to prevent the coal from caking in the producer. Apparatus meeting these requirements is constructed on the system of Dr. Mond. The temperature of the fuel in the producer is by the introduction of steam in large quantities, held sufficiently low to prevent caking, and the gases, in leaving the producer, pass through a zone of high temperature in which an almost complete combustion of the tar is effected. The gases are then cooled and freed as far as possible from moisture, and, finally, the ammonia is saved exactly as would be done in a coke-oven plant. The whole installation is, however, so cumbersome, and its operation so complicated, that the advantages accruing from the economy in fuel seem scarcely to give this method very much superiority over an ordinary steam plant.

In the direct use in gas engines, Mond gas does not offer any advantages over the gases from any other producer, and therefore this system is justifiable only in those cases where the lack of anthracite coal and coke render it necessary to use bituminous coal. The fact that the best recorded economy of a gas motor was obtained with Mond gas in a Premier gas engine does not affect the foregoing statement, as it was due to the fact that the gas engine, as such, was of very high thermal efficiency. On the other hand, the previously described producer plants using anthracite or coke afford a cheap and convenient source of power.

In all the gas producers thus far mentioned, the air and the steam are delivered beneath the grates under pressure. This results in three objectionable features: first, the necessity of continually adjusting the volume of air and steam as the demand for power varies; second, if this adjusting is neglected, the accumulation of large volumes of gas for which there is no demand, under slightly increased pressure, the result of which, should there be any leakage in the mains, is that the gas, which is extremely poisonous and almost odorless, will escape into the producer building; and third, impossibility of access to the grates without previously stopping the operation of the producer. As the slag must be frequently removed from the grates, this third objection is serious, in that it results in interference with continuous operation and renders it necessary either to install duplicate producers or to erect a gas holder of capacity sufficient to tide over the time of cleaning.

THE SUCTION PRODUCER.

It was soon noticed in running gas-producer plants that these operated satisfactorily even when the pressure under the grates dropped to such an extent that the gas engines were forced to draw the gas to their cylinders under partial vacuum. These observations led to the idea of entirely eliminating the fan or injector, and permanently allowing the gas engine to draw its supply of gas from the mains and at the same time to draw air and steam into the producer. This arrangement known as the "suction producer," has proved very satisfactory; it automatically regulates the gas production to meet the demand, no gas can escape from the mains and connections because they are always under partial vacuum, and free access to the grates is at all times possible. The chief modification rendered feasible by this system is the elimination of the steam boiler. No steam pressure being required, all that is necessary is a vessel generating steam under atmospheric pressure, and into which the feed water flows automatically. This type of producer plant consumes no additional fuel for the generation of steam nor does it require the supervision necessary with other systems.

Offsetting the advantages mentioned several disadvantages arise, especially when a number of gas engines draw their supply of gas from the same producer. In such cases it frequently happens that one gas engine will rob the other of its gas, thus causing irregularities in operation; moreover, the pressure in the mains varies within wide limits, and, as the atmospheric pressure remains constant, the composition of the gases produced changes continually, and this too tends to uncertain regulation in the gas engine.

The firm of Julius Pintsch was one of the first to install and actually operate a suction gas plant on a large scale, and in this plant overcame the above-mentioned difficulties by the introduction of suitable pressure regulators in the gas and air mains. This type of pressure regulator is patented in the United States under the name of B. Gerdes.

The principal impurity in suction gas generated from anthracite coal or coke is dust, and this is generally removed in a wet coke scrubber of the kind already described. Further purification and the removal of moisture are accomplished in a dry purifier, in which the filtering medium is sawdust, excelsior, or similar material.

THE ROTARY GAS ENGINE.

MUCH on the possibilities of the gas turbine is printed in engineering magazines of the day, and it must be admitted that there are certain advantages to be gained in the use of that form of motor. At the same time there are certain obstacles in the way of its successful operation which make the turbine impracticable, at least in almost every form yet devised. Chief of these difficulties is the inability to keep the temperature of the blades below the point of oxidation, which renders them brittle and useless. Several ways of overcoming this difficulty have been suggested, but no one so far seems to have been able to surmount the mechanical obstacles presented. A little study of the faults of the common reciprocating gas engine has led the writer to the belief that there is a greater chance of success in the field of the rotary gas engine of the explosion type than in the turbine. The rotary has no greater cooling problem than the reciprocating engine, and it is quite possible to get one, two, or even three explosions per revolution, instead of one every alternate revolution, or, at best, one each revolution, as in the ordinary four-cycle and two-cycle types.

If in the reciprocating engine two impulses are obtained per revolution, it must be in the two-cycle double-acting type, with pump and one cylinder, or two-cylinder two-cycle single-acting crosshead type, or four-cylinder four-cycle type. Any of these have a great multiplicity of parts, and the first two are open to the serious fault of all two-cycle engines, viz., that of imperfect scavenging, which allows a large amount of burned gases, varying with the back pressure of the exhaust, to be mixed with the incoming charge. This mixture of the gases is very liable to cause back firing. In the four-cycle type nearly a fixed amount of burned gas is left in the ports, explosion chamber, etc., which, as in the two-cycle, is mixed with the new charge. This amounts to from one-sixteenth to one-quarter of the entire volume of the cylinder, varying with the compression. If the compression is high, the amount is less in proportion, but increases rapidly as the compression is lowered. No such trouble would be encountered in the rotary, as it could be made to scavenge almost perfectly and obtain the full benefit of a clean charge.

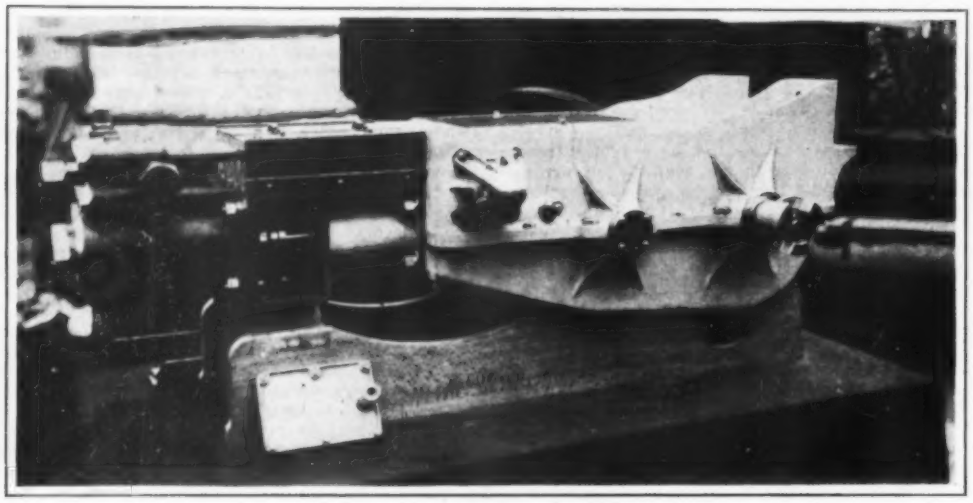
Even more than the turbine the rotary would reduce the size per unit of power over the common type, due to the fact that the rotor of the turbine would of necessity have to be made large to keep down the angular velocity, while the rotary could be made as compact as possible. The greatest advantage, however, of the rotary over the reciprocating engine would be, that the power of each impulse is applied constantly on the tangent; hence, the turning moment would be always equal to the pressure at any point, while in the reciprocating type the turning moment varies for small close-connected engines approximately as given in the accompanying table:

	Pressure.
Beginning of stroke	0.00
⅛ of stroke	0.444
¼ of stroke	0.668
⅜ of stroke	0.84
½ of stroke	1.00
⅝ of stroke	0.75
¾ of stroke	0.60
⅞ of stroke	0.44
Full stroke	0.00

This variation is due to the imperfection of the crank and connecting rod as a means of power trans-

mission. The above factors, coupled with the constantly varying pressure, which falls rapidly after the beginning of the stroke, make the average turning moment only about 0.45 of the average pressure on the piston. The rest of the pressure, about 0.55, is simply lost in strains and friction.

Another advantage of the rotary over the common



THE DARRACQ-SERPOLLET MOTOR.

type is its compactness, the rotary having something like 8 to 1 the advantage in cubical space occupied, and about 3 to 1 in floor space.

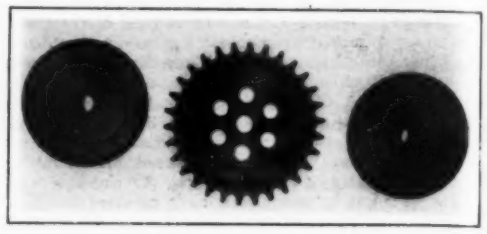
Owing to the comparatively small cylinder volumes to piston areas in some forms of rotaries, the volume of gas consumed would be, theoretically, nearly 40 per cent less than in its reciprocating competitor. In practice it would in all probability not more than equal the common types, owing to the difficulty of keeping rotary cylinders tight enough to prevent leakage without undue friction.

There is one thing in the rotary, however, that promises to be a little difficult, and this is its lubrication. But this is far from an impossible problem, although a somewhat complicated one, owing to the number and location of places that require oil.—W. R. Chalmers in the Engineer.

NOVELTIES OF THE PARIS AUTOMOBILE SHOW.

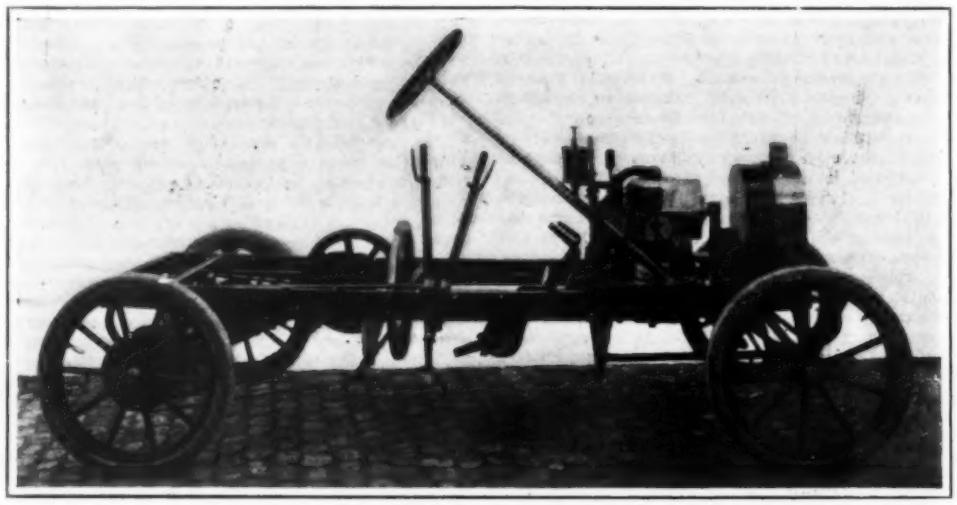
By the PARIS CORRESPONDENT OF SCIENTIFIC AMERICAN.

THE DARRACQ-SERPOLLET CAR.—The Darracq and Serpollet companies have entered into a combination for constructing heavy-weight cars, and especially types of steam omnibus either for private use, such as a large touring car, or for public service, such as omnibuses. In all cases the chassis is fitted with a newly-designed Serpollet steam motor supplied from a flash-tube boiler. Now that the matter of automobile city omnibus lines is receiving so much attention, the new type of car is in the line of progress. It is claimed to have many points of superiority over the gasoline motor omnibuses like those that have been running in London for some time past, and machines of this type have lately been put on several lines in Paris. Taking as an example a thirty- or forty-seat omnibus of this type the weight of the car complete is about seven tons. The disadvantages of the gasoline bus soon became apparent in the frequent starts and stops that must be made, for, although the gasoline motor gives sufficient power, statistics show that there is a great strain on the numerous mechanical transmission devices between the motor and the rear wheels, such as the friction clutch and change-speed gears, and from these come most of the breakdowns and expenses for wear. In the present steam system the mechanical part of the chassis is reduced almost to the motor alone, which carries in its oil-tight gear-case a single pair of gears which drive the differential. From the differential countershaft the drive is carried to the rear wheels of the car by means of sprockets and chains. The mechanism is thus very simple and not likely to get out of order. If we examine what takes place on starting the car either on a level or on a heavy grade, it is seen that with a gasoline motor the clutch must transmit powerful and sudden torque which makes a hard strain upon it; then the gear-changing device is to be worked successively to different speeds before coming to the normal. There is a great fatigue of these parts and the mechanic must be skillful and pay some attention so as to save the strain on the mechanism. With the Darracq-Serpollet system, however, operation is much simpler. With the car running, the motor works at its mean pressure of about twenty atmospheres. On stopping for passengers, the motor ceases to work by simply closing the throttle—that is, by lifting the pedal. But at the same time the steam pressure in the boiler and pipes rises to thirty-five atmospheres, so that there is plenty of steam for starting the car again. The chauffeur, without any difficult maneuver, has only to press lightly upon the pedal and the reserve power operates the starting in a very easy manner and without strain. Should the car be stopped in a bad place in the road, it can be readily pulled out by allowing the small steam boiler feed pump to work and bring up the boiler pressure to fifty atmospheres, which gives a great power to the motor without any risk. As regards the motor, the principle is essentially the same as is used in the Serpollet system, but the form has been modified, as will be observed.

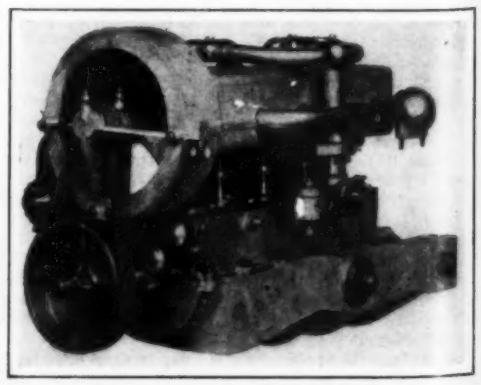


PARTS OF THE TURICUM DIFFERENTIAL.

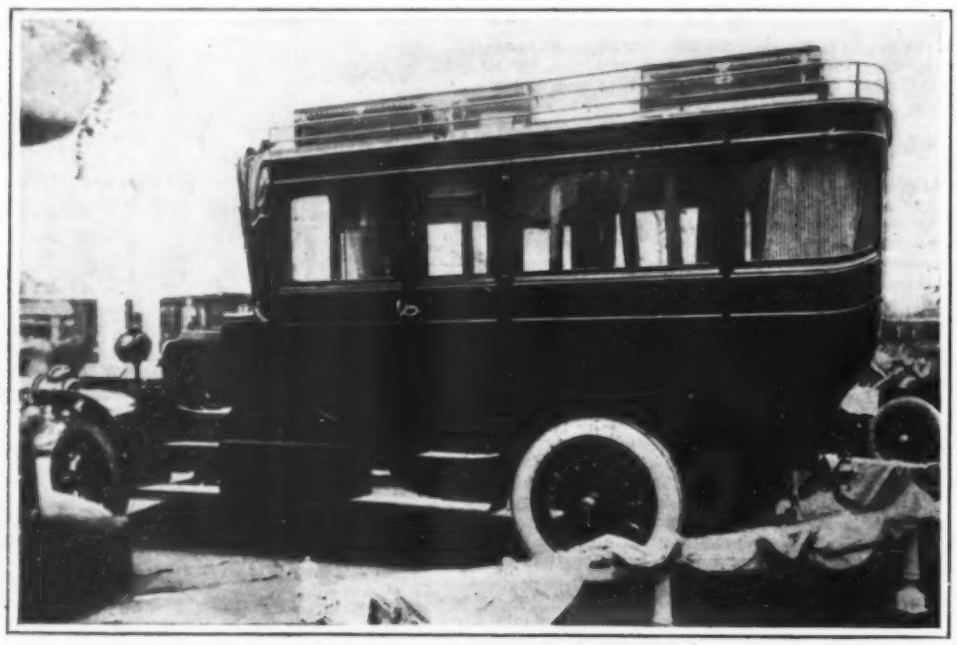
THE TURICUM VOITURETTE.—This new car, which differs in many respects from the standard types, is brought out by a Swiss company of Zurich. It has a two-cylinder motor mounted in front and having, on the upper part of the cylinders, a fan lodged in a special chamber which is cast with the integral air jacket surrounding the two cylinders. The fan is driven at high speed by a belt from the motor shaft, and is sufficiently powerful to cool the motor. The most novel point about the Turicum car is the fact that the movement from motor to rear wheels is transmitted by friction wheels, so that by sliding the movable friction wheel along the shaft any speed desired can be attained within the limits of the design. A special lever device is used to shift the wheel from the driver's seat. From the countershaft which carries the sliding wheel, a driving chain goes to the rear axle on one side only. The friction wheels are so designed that the adhesion of the two wheels is greater according to the effort which is to be overcome by the motor, and thus the device is not of the same kind as where the friction is carried out mechanically by means of a lever. The details of the friction wheel device have not been made public, but the principle will be easily understood from the general view which is shown here. Mounted in connection with each of the rear wheels and receiving the chain, is a combination sprocket



THE TURICUM FRICTION DRIVE CAR.



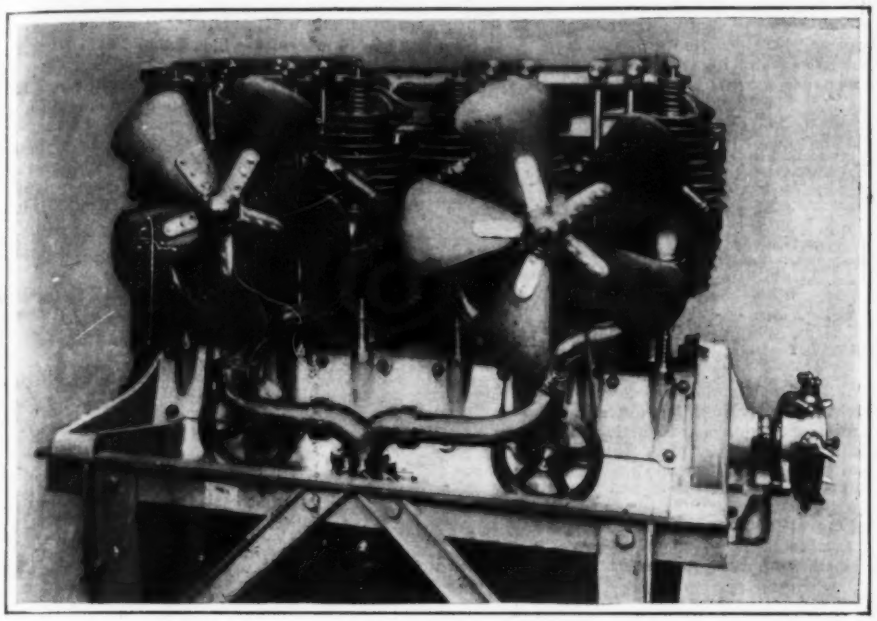
THE TURICUM AIR-COOLED MOTOR.



THE DARRACQ-SERPOLLET OMNIBUS.

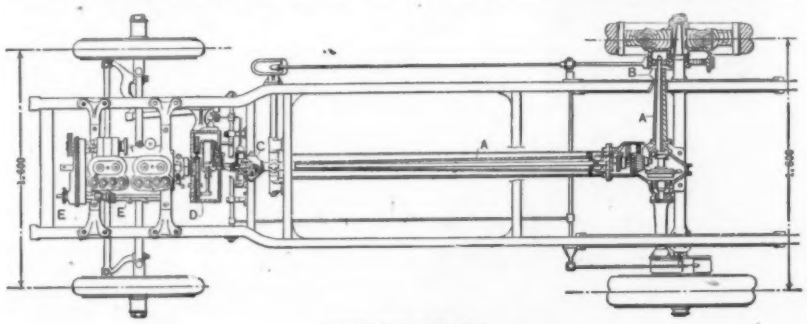
NOVELTIES OF THE PARIS AUTOMOBILE SHOW.

wheel and differential which will be observed in the detail views. The differential is composed of an outer casing which has a set of teeth around the exterior and in the inside contains a disk portion carrying a set of planetary gears at short intervals around the circumference. Meshing with the planetary gears are two crown-wheel disks. Each of the disks is connected to one of the rear wheels, so that the whole device gives the differential action and is very light, having a great number of teeth always engaged, which increases the strength of the device.



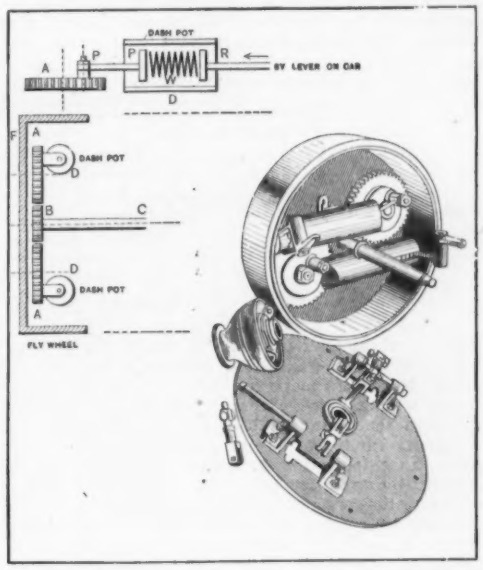
THE HENRIOD AIR-COOLED MOTOR.

HENRIOD MOTOR.—The object sought for in the new motor which is brought out by the Henriod firm in connection with the Société Neuchateloise is to provide a practical system of air cooling for a four-cylinder motor of the usual automobile size. This problem seems to have been successfully solved in the Henriod-Schweizer construction which we illustrate here. Needless to say, such an air-cooled motor has great advantages over the water-cooling method from absence of radiator, pumps, need of water supply and attention; also the weight is less, hence a less wear upon the tires. Experiment shows that 170 liters of air replace a liter of water for the cooling. To give the proper result, the inventors increase the cooling surface of the cylinders by means of a newly-designed system of radiating wings, combined with a strong draft given from the air fans. It is found with this method that the motor keeps cool, and this is true even in severe trials which it may have, such as the ascension of the Weissenstein, where the grade is 25 in 100, during one of the warmest days of summer. This certainly speaks well for the new method, and its advantages are being recognized by automobile constructors.



HENRIOD CHASSIS.

THE HENRIOD PLANETARY GEAR CLUTCH AND INCLOSED PROPELLER SHAFT.—The C. E. Henriod Company also shows a chassis which combines several new devices. We give a view of the chassis taken from the rear end, and it will be noticed that the mechanism has an especially simple and solid appearance. This is due to the use of what is known as the hollow shaft speed-changing system, which has been used with great success. The characteristic of the system lies in the fact that the universal-joint rod which connects the motor clutch with the speed-changing gearing and differential is inclosed in a straight tubular piece which is connected at one end with the front mechanism and in the rear to the gear box. A similar tube runs crosswise and surrounds the rear axle, so that the whole mechanism is protected by a covering of a T-shape. The principal advantage in the use of the tubular covering lies in the fact that this part alone bears the weight and all the strains, leaving the connecting rod and the rear axle parts entirely free from the shocks of the road, thus giving much less strain upon the mechanical parts of the car, so that they now have no other function save to transmit the movement from the motor to the rear wheels. Where the tubular portions join on to the fixed parts, a well-designed articulation is used, so that this portion follows all the movements of the chassis of whatever kind while at the same time supporting the strain. The differential casing is cast together with another portion which serves to contain the speed-changing gears, so that the whole lies in a very compact form, as may be seen by comparing this with the usual type of chassis. As to the new Henriod motor clutch, we expect to give a more complete description of it later on, but will briefly mention its principle. It is an all-metal clutch, but is distinguished by the fact that it works without friction by means of a set of springs which are compressed by pedals. The motor flywheel, *F*, is hollow, and inside it are mounted a pair of planetary gears, *A A*, which work on either side of a pinion, *B*, mounted on the shaft, *C*, which leads to the rear of the car. As the flywheel rotates, the planetary gears are carried with it, and as they run loose, they do not turn the central pinion. But by blocking the gears they jam and turn the pinion. Each gear carries an eccentrically mounted piston rod, *P*, which works a piston, *P'*, contained in a dash-pot, *D*. The damping movement is given by a coiled spring, *W*, in the dash-pot. Putting pressure on the spring at *R* from the other side by a pedal causes the piston's movement to be lessened from full action down to zero, and we thus have a starting clutch which works without friction, which is a great advantage and is claimed to give, in the case of heavy cars, all the elasticity of steam. As a proof of the value of the hollow-shaft system mentioned above, it has been adopted by the Darracq firm after a long series of tests.



HENRIOD CLUTCH AND PLANETARY GEARING.

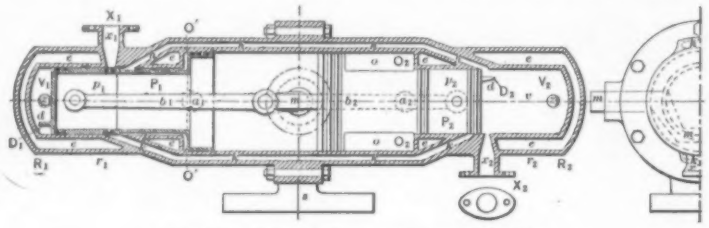
KRIEGER CAR.—An improved gasoline-electric car is shown this year by the Krieger Company. On the front of the car is mounted the gasoline motor in the usual place. Coupled direct upon the motor shaft is a dynamo which works together with a storage battery. The current from the dynamo is sent into two small electric motors placed directly against each of the front wheels of the car and driving them by a reduction gearing. We have already pointed out the general advantages of the gasoline-electric system; hence we will mention only some of the new points about the car, which consist in the use of a four-cylinder Brasier gasoline motor, connected to a four-pole dynamo of cylindrical form which is observed in the engraving. Back of the dynamo is mounted the controller, inclosed in a metal case. The dynamo is designed for 24 horse-power, and works from 600 to 1,400 R. P. M. in general. It has three windings for magnetizing the fields, consisting of a series and a shunt winding, also a third coil connected with the storage battery which can neutralize the action of the others and demagnetize the field. By combining the different circuits any desired current can be secured, and the speed of the wheel-motors regulated accordingly. The storage battery delivers about forty volts, and is of light weight. As to the electric motors mounted against the front wheels, they work on a spring suspension and hang near the ground. Each motor is designed for 16 to 20 horse-power, and runs at 1,200 to 1,600 R. P. M. The

THE KRIEGER GASOLINE-ELECTRIC CAR.

NOVELTIES OF THE PARIS AUTOMOBILE SHOW.

controller is of a new form and has a set of carbon breaks so as to take up the spark.

VICTORIA MOTOR.—This new motor is one of the most remarkable to be seen at the show, and contains a number of original features which give it not only a great simplicity in mechanical construction but many other advantages which we shall mention. Most of the motors used in France and many other countries are of the four-cycle type, giving an explosion per cylinder for four strokes of the piston. Such motors contain valves and their springs, gears and cams



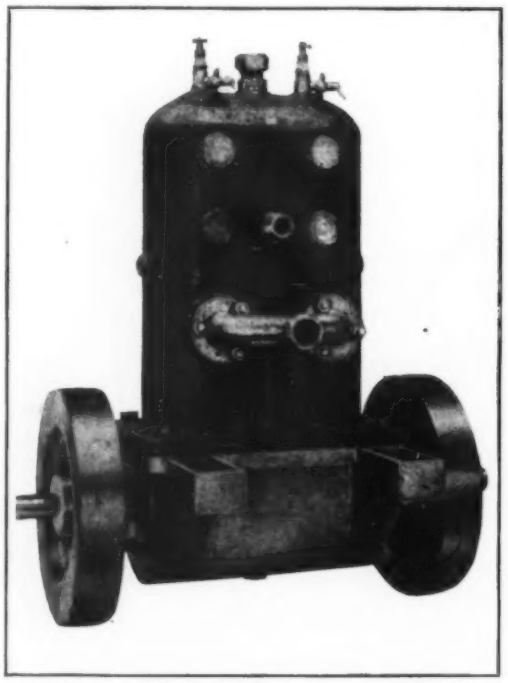
VICTORIA HORIZONTAL TWO-CYCLE MOTOR.

which are complicated and can easily break down. With low carbon gas, which is coming into use, the disadvantages are more apparent owing to impurities. Again, with a four-cycle motor we need to have four cylinders to obtain the best running conditions and regularity, and this is recognized more than ever seeing that four-cylinder motors predominate at the show to the exclusion of others. It is only with four cylinders that we obtain from a four-cycle motor two explosions per revolution of the shaft, so as to give a steady running. For some time past, inventors sought to build a two-cycle motor, in which each cylinder gives an explosion for each revolution of the shaft. The German Körting motor is an example of this type, but it is built especially in large sizes up to 1,200 horse-power. In their new Victoria motor for automobiles, launches, or stationary work, the inventors, C. E. Kolb and Réné Champly, claim to have found a type which realizes the end sought for in a two-cycle motor.

Referring to the section, the motor contains two sets of cylinders whose pistons work on a common crank-shaft at the center. When piston P_1 leaves the cylinder end, carbureted gas is drawn into the annular space O_1, by a small automatic valve, a_1. On the return of the piston the gas is compressed in the annular space. When the piston comes to the end of its stroke, the piston P_2 of the other cylinder uncovers the opening of a gas tube (cast in the metal) and the compressed gas comes over and enters the cylinder R_2, in the explosion chamber V_2. The left-hand annular cylinder thus acts as a gas pump for the right-hand main (or explosion) cylinder. As the piston P_2 mounts in the cylinder it again compresses the gas, then the spark gives the explosion and the piston is driven out. The burned gas escapes by the free opening, X_2, which has no valve, when the piston comes to the bottom. During this time the annular cylinder O_2 and its piston have supplied in turn the working cylinder V_1, which also gives an explosion. Thus we have for each cylinder group and per revolution of the shaft, two gas-feeds and two explosions followed by two exhausts from free openings, or in other words, the same result as with a 4-cylinder four-cycle motor, with simplified parts. Here the pistons themselves act as slide-valves. Each has a deflector D_1 D_2, which sends the fresh gas to the cylinder end, where it is in contact with the spark, and the gas entry drives the burned gas out by X_1 X_2.

Ignition is carried out by simple contacts placed against the flywheel. The consumption of fuel is an important point in its favor, and this is only 0.5283 quart of gasoline per horse-power-hour. Inasmuch as the motor runs steadily from securing an explosion every half-revolution, it can have very light flywheels, allowing a quick stop of the motor, and a reverse by simply shifting the commutator. The quality of reversibility is to be noticed, as the motor can be run at will and instantly to right or left without having to re-start it. A special ignition handle is all that is needed to reverse the motor, and this is valuable for cars, boats, or machines. A 15-horse-power horizontal motor running at 400 R. P. M. weighs only 660 pounds. We also illustrate a vertical motor of the same power having the two cylinders side by side with two cranks on the shaft. It runs at 800 R. P. M. and weighs only 220 pounds.

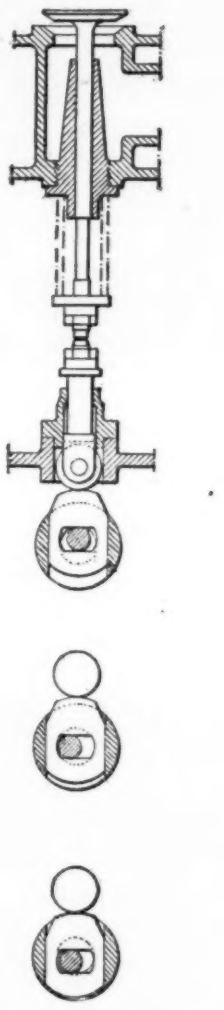
THE CORNILLEAU AND SAINTE-BEUVE CAR.—The motor which is designed by this firm presents several points of novelty. In the first place it is constructed so that the different parts needed for operating the motor, such as the magneto, oil pump, starting device, etc., are grouped in a single compact piece which can be readily adjusted to the chassis. All the moving parts of the motor, and even the valve-rods and igniters are inclosed in a tight case, but it is easy to reach them by simply taking off four large side covers, which give access to the inside of the motor. Lower down, two oval covers allow of reaching the crank and the cam-



THE VICTORIA VERTICAL TWO-CYCLE MOTOR.

shaft. Almost all piping is absent in this motor, since the four cylinders are cast in a single piece, with openings which themselves form the piping for the inlet and exhaust. This allows of using a single water-jacket so as to give a uniform cooling for all four cylinders.

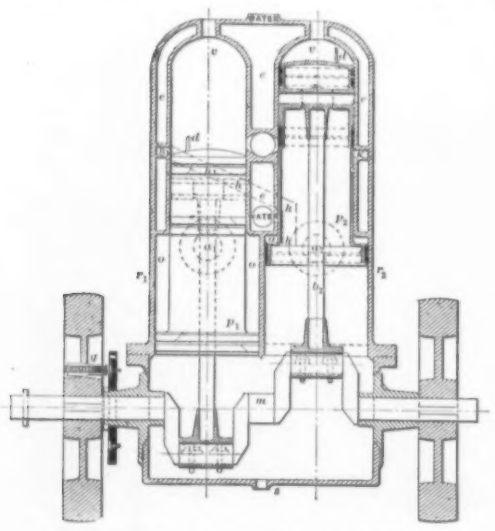
What is also novel about the motor is the method of speed control, which is carried out by a special device giving a variable inlet at the admission valve, and the motor can thus be controlled by a single handle placed upon the steering wheel. To carry out the variable inlet system, the cam which operates the inlet valve is not fixed as usual, but is made movable in the following way so as to give a greater or less opening of the valve. The inlet cam shaft is hollow, and opposite each valve rod is mounted the special cam which can slide in and out of a socket so as to give a greater or less push upon the rod of the valve. In the hollow cam shaft is a rod which runs along the entire length, and at each of the cams the rod carries an eccentric device which, when turned about, causes the cam to slide in or out, and the four cams are thus operated at the same time. Where the rod leaves the end of the shaft it has a pinion mounted on it which works with a bevel gear on the end of a long rod leading to the driver's handle. With the handle in the first position, the cams are raised out of their slots to their highest point, so that the inlet valve gives its highest lift off the seat and the maximum inlet. Push-



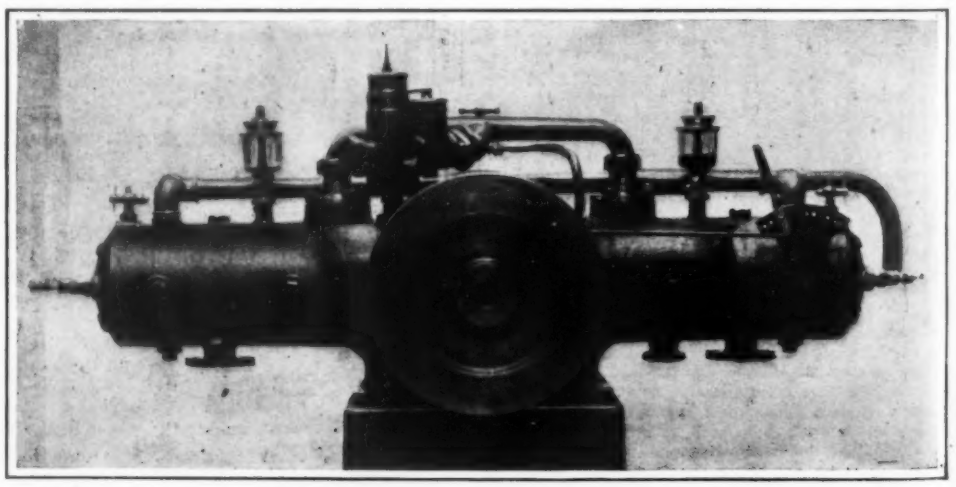
CAM AND SOCKET DEVICE OF THE CORNILLEAU-SAINTE BEUVE MOTOR FOR CONTROLLING THE INLET VALVE.

ing the handle to the back causes the cams to slide entirely into the sockets and disappear, and they no longer raise the valve, thus there is no inlet. In this way the motor can be controlled at any speed, and the device is mechanically simple, with but few working parts. When the inlet is entirely closed we obtain a braking action on the motor, thus allowing the car to run at a slow speed on the down grades with but little use of the hand-brakes.

The method of operating the ignition is another new point about the Cornilleau and Sainte-Beuve motor. Current is furnished by a magneto, but using a



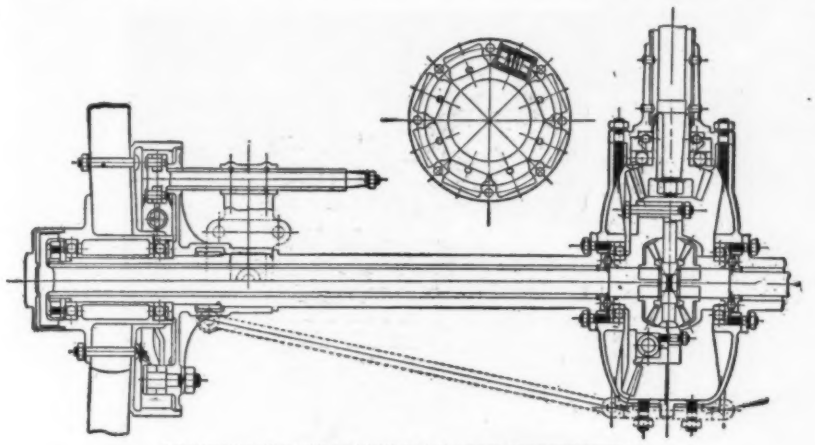
VICTORIA VERTICAL TWO-CYCLE MOTOR.



THE VICTORIA TWO-CYCLE HORIZONTAL MOTOR.

NOVELTIES OF THE PARIS AUTOMOBILE SHOW.

device which suppresses all the wiring. The make-and-break igniters are placed in the cylinder heads just above the inlet valves. They are not operated in the usual way from the outside, but have a special device which operates them from a cam on the valve cam shaft mentioned above. In the cylinder head the spark occurs between a curved hammer and a stationary anvil. The hammer is mounted horizontally on the end of a vertical rod, so that turning the rod



CORNILLEAU-SAINTE BEUVE ELASTIC DIFFERENTIAL.

makes the contact and *vice versa*. In order to turn the rod, the lower end has a tail-piece which works in a cam mounted along with the valve-cam, but this cam is formed along a vertical portion of the disk, so that when the cam shaft revolves the tail-piece is pushed around and thus rotates the vertical rod, and therefore makes or breaks the spark contact in the cylinder-head. By taking off the cylinder cap the igniter is easily inspected or regulated, and the whole device is contained inside the motor.

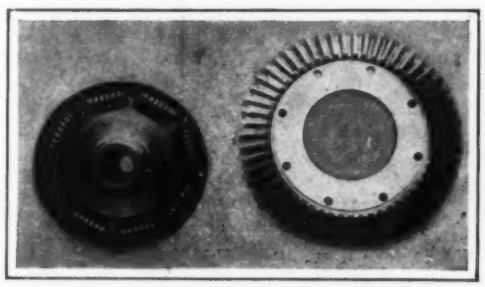
Upon the same car is mounted a device which we illustrate here, consisting of an elastic differential. It is designed so as to give an easy start to the car and preserve the gear teeth and other mechanical parts from violent shocks. This result is obtained by placing a device between the main bevel-gear of the differential and the box containing the planetary gears, consisting of a set of springs which are lodged in sockets so that they are entirely inclosed. These springs always work by compression, and thus in the same way for front or rear motion of the car, and they are so calculated that the power is always applied through an elastic cushion. When starting the car, the springs will yield so that the flywheel can make a half turn before they are compressed. The elasticity which is secured not only takes the shock off the mechanism, but gives a gradual movement in starting the car and saves considerable wear of the tires.

THE STERILIZATION OF MILK.

IT must be acknowledged that we are somewhat puzzled when it becomes a question of sterilizing milk in an absolutely certain manner and without danger to the organism, especially for the feeding of children. Moreover, scientists themselves, when consulted, are not precisely agreed as to the process to be used in order to reach the result desired. Some of them, even, who appear to be invested with high scientific authority, occasionally propose antiseptics which are soon denounced as condemnable from a hygienic standpoint, or else powerless as regards microbes. We shall take for example only the addition of formol in the proportion of 1/5,000 to 1/10,000 advised by Behring. As stated by this scientist, the ingredient in question, in the proportion just mentioned, does not destroy the pathogenic microbes, but merely arrests their prolification. According to M. Trillat, formol unfortunately combines with caseine, and renders it partially inassimilable, and, besides, a portion of it, remaining free, attacks the mucous membrane. But that is not all. Leo Schaps has found that even if, at one per cent, formic aldehyde prevents the development of lactic ferments, it offers no more opposition to the multiplication of staphylococci than it does to that of bacillus tuberculosis. He found upon an autopsy of a child fed upon milk treated with formol, some lesions produced by the chemical ingredient.

Before so serious affirmations, the learned professor of Marbourg and his two coadjutors, Roemer and Much, advise oxygenated milk, which they prefer to milk treated by a high temperature. A small quantity of oxygenated water is added to the milk, which is heated and a few drops of hepine, a soluble ferment, combined with it. It is possible to use the milk thus treated two hours afterward, when it will be found to contain no microbes and to be perfectly digestible. It can be preserved longer if protected from the light. In 1899, M. Jamois recommended red light for this purpose.

M. A. Renard, as long ago as 1898, proposed the proportion of two per cent of oxygenated water to 12 volumes. As a consequence of a catalytic phenomenon, this water is decomposed, and, in from six to eight hours, none of it any longer remains. It has been found that milk thus treated is not sterilized, but keeps longer than does ordinary milk. Although the number of bacteria decreases considerably during the eight or ten first hours, it afterward gradually will communicate a metallic taste to the food. Messrs. de Waele, Sugg, and Van der Weide have proposed also to compensate for the insufficiency of decomposition, by milk, with oxygenated water in excess by adding the soluble ferment that effects such transformation, in the form of sterilized sanguine serum. Although the latter is previously sterilized, it is necessary to contend with the negligence that is always possible in manipulations. According to M. Budde, it would be possible to adhere to small proportions of oxygenated water; but, on the contrary, we should by far increase the microbicide action of the oxygen by causing it to act concurrently with a suitable temperature in a closed vessel. Thus, a simple proportion of 1-20 per cent, and an immediate heating for seven or eight hours at 50 deg. C. give milk that is completely sterilized, and no longer contains any oxygenated water. The "buddized" milk has been tried at Copenhagen, Berlin, and London, and it has been found that the coli bacillus, the typhic bacillus, and the diphtheric bacillus disappear in an hour, and Koch's bacillus in four hours.

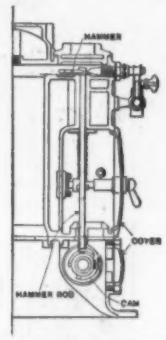


CORNILLEAU-SAINTE BEUVE DIFFERENTIAL.

As for sterilization by heat, that has a great number of defects imputed to it. Dr. Behring disapproves of the high temperature to which milk treated in a digester and industrial milk are submitted because of its destruction of several principles which make the liquid an aliment endowed with life, so to speak. Thus are destroyed hydrolyzing or oxidizing soluble ferments with biochemical action, direct ferments (properly so called), or indirect ferments (anaeroxydases). And, again, the milk perhaps contains some alexines also and some ctolytics capable of destroying the microbes or of digesting foreign cells.

Upon the whole, milk treated in a digester, although it frees our organism of all microbian risks, unfortunately no longer constitutes anything but an indigested aliment of less nutritive value. Aside from the destruction of the diastases, other imperfections are ascribed to it, such as the destruction of sapid and aromatic substances, a burnt taste, a yellow color, a diminution of the lecithines and citric acid, insolubility of the caseine and phosphate of lime, and often the absence of gas. Despite this, Dr. Variot does not fear to take up the defense of milk sterilized by heat. In fact, it is the only preparation free from the pernicious action of microbes, which have not yet had time to secrete toxines.

Some would prefer, however, to have the milk simply boiled on a water-bath. (We do not speak of pasteurization, which is by far too inefficacious). The objection again is made to such preference, that the white liquid thus treated presents pretty nearly the same physico-chemical modifications as milk treated in a digester, and that, in addition, it is not immune from microbes, since it often curdles without becoming acid in sometimes taking on a bitter taste. And then are there not authors who have ascertained in experiments *in vitro* (in the language of scientists who do not find



CORNILLEAU-SAINTE BEUVE IGNITER

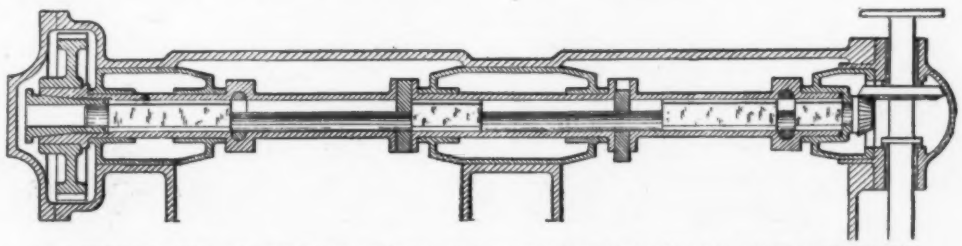
the French vocabulary rich enough), that the superheating of milk increases its digestibility, especially that of its albumenoid substances.

As a conclusion, we would say that the sterilization of milk by the digester at 110 deg. C. for ten minutes, and immediately after being drawn from the cow, appears to be, in the present state of our knowledge, the most recommendable process for dealers who supply cities with this aliment. A complementary operation consists in first heating the liquid from 75 to 80 deg., and at the same time stirring it for the purpose of expelling the dissolved oxygen, a gas which favors the aerobic ferments. Afterward, it is bottled and placed in a digester.

Since we are speaking of sterilized milk, let us mention a somewhat surprising fact ascertained by Dr. Dufour, of Fecamp, in his "Goutte de Lait." As well known, the doctor is the initiator of this philanthropic work, and has had numerous imitators in many cities. The fact is also known that the "Goutte de Lait" and other analogous institutions are designed to furnish good sterilized milk to indigent mothers, and, at the same time, to give the latter advice upon infantile hygiene. Well-to-do people also can profit by these great advantages, but by paying therefor, as might be expected. Well, Dr. Dufour has concluded from the statistics that he has drawn up, upon the infantile mortality in his service, that despite the fact exactly the same kind of milk was furnished to the poor and the rich, fewer children of the rich died. He attributes this difference, surprising at first sight, and well marked, moreover (9.63 per cent in the families of laboring people, 4.2 per cent in families in moderate circumstances, and 2.87 per cent in well-to-do families), not only to various causes, such as heredity, with which are connected alcoholism, tuberculosis, etc., but also to unhealthy houses. For our part, we should like to add to these various factors of morbidity the faulty manner in which milk, even sterilized, is administered to babies, and the little regard paid to cleanliness in connection therewith; and the observation of the elementary rules of hygiene met with more in persons in easier circumstances and better educated.

We might recall apropos of this that in schools, it would be possible to reserve a place in courses on domestic economy or hygiene for some ideas in regard to infantile pedagogy and puericulture.—Translated from the French of P. Santolyne in Cosmos for the SCIENTIFIC AMERICAN SUPPLEMENT.

Photographs of Manuscripts or Printed Matter in Libraries.—Such photographs are frequently required singly and at the lowest possible price. They may be made, according to a communication by Richard Wiedemann in the Wiener Mitteilungen Photographischen Inhalts, by taking the picture by means of a mirror placed at an angle of 45 deg. in front of the object. The picture is taken on negative paper, and can be used immediately after developing as a positive copy. The writing, etc., will appear white on a dark ground, which, however, will be no detriment to its availability for purposes of research.



CONTROLLING ROD FOR WORKING INLET-VALVE CAMS OF THE CORNILLEAU-SAINTE BEUVE CAR.

NOVELTIES OF THE PARIS AUTOMOBILE SHOW.

ELECTRIC COOKING.*

By DAY ALLEN WILLEY.

THE use of the electrical current in domestic occupations is one of the most interesting features connected with its service as a substitute for other forms of power, illumination, and heat. The electric lamp has become a common article in connection with the household, thanks to the many improvements which have been made to it within the last few years, but it must be admitted that despite the efforts to perfect methods of what might be termed electrical cuisine, as yet the kitchen in which the current is utilized is a novelty.

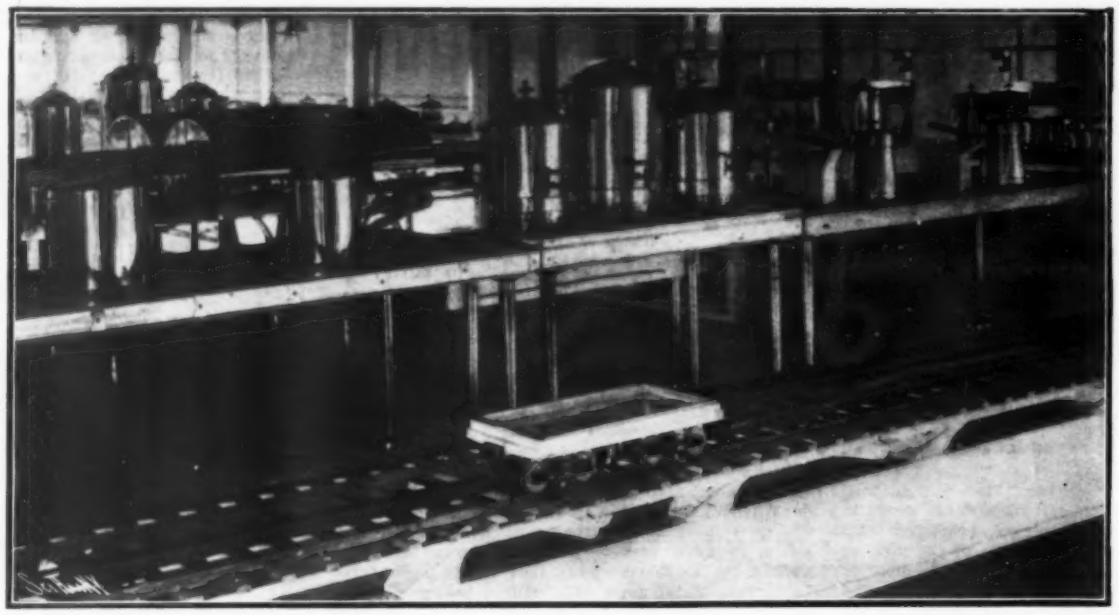
To women especially, the idea of electric cooking is fascinating, since the housewife appreciates not only the labor, but the truly enormous amount of waste which seems indispensable in using the ordinary cook stove or range She may not be aware that no less than 95 per cent of heat generated from the wood or coal is wasted, and that to secure enough to prepare the meal she must actually burn nearly twenty times as much fuel as necessary; but in a general way she knows that even where gas or some form of petroleum is employed, here also more heat is produced than is actually required for her purpose. It is unnecessary to say that one of the greatest objections to modern housekeeping is the preparation of food in the ordinary way, despite the many improvements which have been made to culinary apparatus. Possibly this was one reason why those women especially who have visited the World's Fair had their attention so attracted to what has been termed the electrical kitchen. Here could be seen a variety of dishes, such as are served in an ordinary city restaurant, yet not a pound of coal or wood was consumed in creating sufficient heat to prepare them. The electrical current furnished it all, the various circuits providing enough to supply meals to fully five hundred persons an hour.

The kitchen itself comprised a bench about three feet in width and twenty-odd feet in length, which was equipped with heating apparatus for boiling, baking, broiling, toasting bread, heating the coffee urns, etc. There were ovens in which bread and rolls were baked as well as meats. The vegetables were cooked in kettles, while the meats were served in most of the usual ways. The kitchen even included heaters for keeping dishes warm. The temperature in the electrical restaurant was but slightly warmer than in other parts of the building, while the absence of the odor of the cooking was especially noticeable. During the time it was in operation, it was one of the most popular resorts at the fair, especially because the viands served were so well cooked and so palatable.

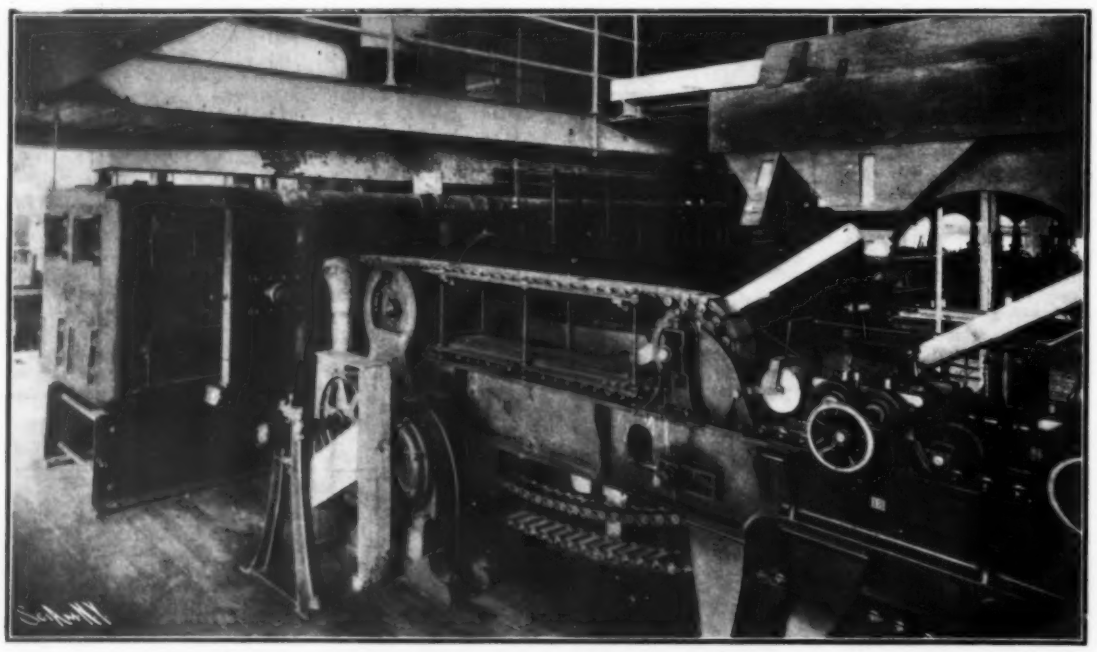
While this form of cooking is as yet a novelty, there are good reasons for believing that it will come into more extensive use not far in the future, as the cost of generating current is reduced. Already electricity is being obtained at such a small expense in certain localities that its expense is little in excess of other fuel, while its advantages over solid and liquid heat generators gives it preference. The current secured from Niagara Falls is produced at such a small sum that, as readers of the SCIENTIFIC AMERICAN are aware, it is employed exclusively for power in some of the larger industries, and especially in the preparation of food products, as was recently described and illustrated in these columns. At the plant of one company the employees are served at a restaurant where all of the food is electrically prepared. In the manufacture of what is known as triscuit the electric oven illustrated in the accompanying photograph is utilized, the triscuit being actually baked as it is formed. The layers of filament composing the wafer are pressed together by metal molds which are heated by an electric current. In this way the product is ready for use as soon as it is automatically delivered from the oven to the packing table.

At the plant referred to the electricity is distributed in such large quantities that it can be secured at a comparatively low rate. In fact, the current is like many other manufactured commodities—if the market for it is sufficiently extensive, the manufacturing company can afford to distribute it more cheaply. This point is worth noting, as in many other parts of the country, where water power is the source of electrical generation, it is not improbable that the current can be supplied for domestic purposes at a rate which will allow it to be substituted for other forms of fuel, especially in communities which are at a distance from the coal-mining centers. The schedule of prices for this source of energy varies so greatly that it is impossible to make a close comparison of its expense and that of other forms of fuel, excepting gas. If the latter is sold to the consumer at the rate of $1.25 for each thousand cubic feet, electric current served at the rate of one cent per horse-power per hour is considered to be equal to it. So economically has electricity been generated, not only at Niagara Falls, but in some portions of the Southern States, that the manufacturers can secure it as low as the figures quoted. In some of the cities and towns where it is thus transmitted, it could doubtless be distributed from house to house for domestic purposes with a saving to the consumer in the annual fuel bill.

The illustration of an electrical kitchen, which is herewith reproduced, gives an idea of the small space which is required, for it has apparatus sufficient to serve breakfast, dinner, or supper for a large number of people. The tables in the foreground contain the tanks or urns for making beverages and for heating water. Another table is devoted to steamers and heaters for keeping the viands warm, while another is provided with boiling, baking, and other apparatus. As the dishes are ready for the table, they are placed upon little cars, which are propelled along a miniature electric railroad to the dining room, so that it is not



A MODEL ELECTRIC KITCHEN, THE CAR PROVIDES A QUICK MEANS OF TRANSPORT FOR TAKING THE COOKED FOOD TO THE DINING ROOM.



LARGE OVENS FOR BAKING ELECTRICALLY A SPECIAL KIND OF SHREDDED BISCUIT, WHICH IS BAKED AS IT IS FORMED IN THE MOLDS.

COOKING BY ELECTRICITY.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

necessary for the waiters to carry food between the two apartments. Equipment for the kitchen of the home or apartment containing a family of five or six persons can be installed in a quarter of the space ordinarily occupied, including room for the various utensils, since no storage room is needed for fuel, and but a small number of heat units are required.

The possibility that electricity may supersede other forms of heat for culinary purposes has caused electricians and other experts to give much attention to devices for utilizing it economically. Two systems are in more general use in this country than any others. In one, the current is conveyed to a section of wire which is imbedded in a film of enamel to insulate it from other metals and offer a sufficiently high resistance. In the other system, in place of the wire a strip of mica is employed, and is covered with a compound containing sulphide of gold combined with nitro-benzoin and oil. After the mica is covered, it is exposed to an intense heat, being really fired like china. All the organic matter is thus eliminated, and the gold is left burned into the mica. The combination can be so perfectly effected that a current of 200 volts can be applied to it without injury. The heat is radiated from a thin metal plate in which the mica film is incased, after the wire has been attached to the latter. Both of the systems in question will produce a temperature as high as 400 deg. in twenty minutes, and it is calculated that the actual percentage of waste heat is not over 10 in using ovens. For cooking apparatus requiring the most heat, current is conveyed to the units by two or more circuits. When the required temperature has been secured, the current can be turned off all but one of the circuits if desired, so that only the actual supply for preparing the dish need be utilized.

THE STORY OF A LONG-DISTANCE TOURING TRIP IN AN ELECTRIC AUTOMOBILE.*

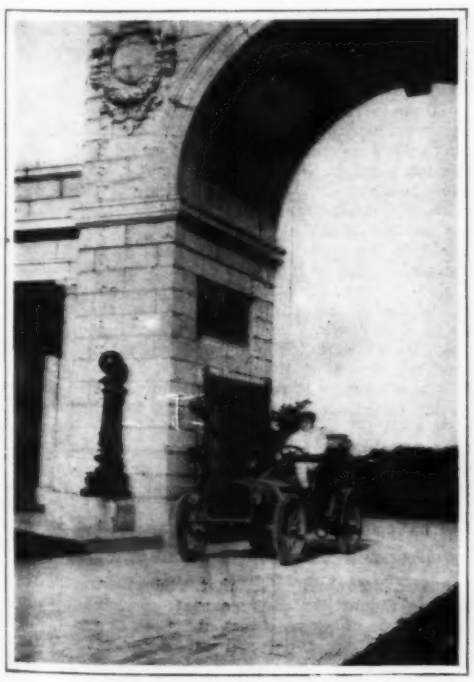
WE started from the Empire Garage, Cleveland, Ohio, at 11:50 September 21, 1906. Nine miles from Cleveland we had a puncture; in repairing the same we got the valve pinched, so that the tire went down again three miles further on. From that point on, we had no more troubles of this kind. The rest of the tires we did not pump up at all in the 314 miles. We arrived at Geneva, Ohio, at 4:30, having gone out of our way three miles. At Geneva our cyclometer registered 47.4. This makes an average speed of 13.2 miles per hour. We put the machine on charge at the Geneva street railway plant for three and one-half hours at a 25-ampere rate. We remained in Geneva over night, and left there at 8:00 in the morning. The road from Geneva to Ashtabula, a distance of 11 miles, was very sandy, but we covered it in 40 minutes, using a comparatively high speed, as we had made up our minds to put the machine on charge in Ashtabula, where they had a regular charging outfit. (We could not get a perfect charge at Geneva, on account of not being able to cut down below 25 amperes.) Our current consumption on the sandy road was 30 to 40 per cent greater than on the level road. At Ashtabula we put in 38 ampere hours at 84 volts. This was done at the Ashtabula municipal lighting plant, and it required an hour and three-quarters. We left Ashtabula at 10:40, encountering some hills, which we were told by gasoline autoists were terrors. The hill called the "State Line Hill" was the worst one. Our gradometer registers up to 15 per cent. On this hill the indicator went off the scale. Just what the grade was, I do not know. Through this part of the country there is a deep ravine, which crosses the road five or six times; therefore we ran in and climbed out of this ravine several times. When we were within 12 miles of Erie, Pa., it commenced to rain, and continued to pour for about two hours. We waited until the rain was practically over, but could not climb the hills, on account of our wheels skidding. We put ropes around the tires, which helped us along. The run from Ashtabula to Erie took four hours and twenty minutes. Our cyclometer registered 44 miles. This was pretty slow.

In Erie, Pa., we were the center of attraction, on account of the novelty of seeing an electric machine that could tour country roads. We were glad to get away from there, on account of the annoyance of being so popular. We stayed over Sunday in Erie, and started at 5:15 Monday morning, arriving in due time in Fredonia, N. Y. We tried to charge from a plant owned by the publisher of The Automobile, but his man could not make the rectifier work. We went on to Dunkirk, and got a good charge there at the Dunkirk Power and Heating Company. We ran from Erie to Dunkirk, 53 miles, in three and one-fourth hours, at an average speed of 16 miles an hour. After charging at Dunkirk for four and one-half hours, we left there at 3:40 for Buffalo. Here we struck an ideal road, especially a little way out of Buffalo. We ran from Dunkirk to Buffalo, a distance of 50 miles, in three hours. Along the lake front we made several miles at 28 miles per hour. At Buffalo we put our machine in at the Babcock Garage on Utica Street, and remained in Buffalo all the next day. We put 150 A. H. in the battery, and left Buffalo Tuesday at 8:30. The road from Buffalo to Batavia was fine. For 8 miles we ran at a speed of 28 miles per hour. We made Batavia in two hours. Our cyclometer registered 36 miles. This was our best time. As we got farther east we gained confidence, and speeded the machine up higher. At Batavia we were charged $2 for 88 ampere hours, by the Thompson Harvester Works. We left Batavia at 3:30, and arrived at Rochester at 7 P. M. The run from Batavia to Rochester was downhill considerably, and for 10 miles we coasted 58 per cent of the distance. We practically ended our run at Rochester, stopping at the Genesee Garage. We remained there over night, putting 150 ampere hours into the battery. At Rochester the writer received a telegram to go to Fort Wayne, Ind. On account of its being late in the season, and the weather man promising rain and plenty of it, we decided to ship the machine back, but before so doing we ran to Palmyra, N. Y., and back. This made our total run 314 miles. I might add that it rained every day for nearly two

* This story of a cross-country trip in an electric automobile shows the touring possibilities of the modern stock electric machine. With a car fitted with a special battery, one hundred miles a day could easily have been made. The average speed was nearly as great as could be made with a gasoline car of ten times the horse power, and the economy also compared very favorably with that of the latter.

ELECTRIC TOURING RUNABOUT HAVING A SPEED OF 30 MILES AN HOUR AND CAPABLE OF TRAVELING 75 MILES ON ONE CHARGE AT AN AVERAGE SPEED OF ABOUT 20 MILES AN HOUR.

THE ONLY TROUBLE OF THE TOURIST WHO TRAVELS IN AN ELECTRIC AUTO.



THE START ON DRY MACADAM.

Current consumption: 98 watts per ton-mile.

AFTER A SPELL OF WET WEATHER.

Current consumption: 100 watts per ton-mile.

A BAD STRETCH OF SAND.

Current consumption: 190 watts per ton-mile.

DIFFERENT KINDS OF ROAD ENCOUNTERED DURING A LONG-DISTANCE TOUR IN AN ELECTRIC AUTOMOBILE.

weeks after; therefore if we had continued our trip east, it would have been very unpleasant.

The construction of the machine was as follows:

Total weight, including two passengers, 2,780 pounds.

Weight of batteries, 975 pounds.

Rated horse-power of motor, 2.

Size of tires, 34 x 4½-inch quick detachable.

Type of machine, double chain drive.

Chassis of the pressed steel type.

Speeds, 10, 12, 14, 24, 30 miles per hour, varying with the condition of the roadbed.

Next year I shall make a run from either Cleveland to New York or Chicago to New York. Several people have signified their willingness to participate. If the weather is good, there is practically no difficulty in touring with an electric; however, if much mud was encountered, it would be impractical.

The cost of current on this run at 5 cents per kilowatt would have been 0.0167 per mile.

I might add in conclusion that with a special machine this trip could have been made in three days at 100 miles per day. The car used in this test, however, was perfectly normal, and the test is a good indication of what can be done with some of the best standard machines of to-day. The car had a maximum mileage of 62 to 70 miles on country roads, and possibly 75 to 80 on city streets. It was equipped with 24 cells of 150 A. H. capacity.

For night work the owner equipped his car with a special lens mirror searchlight fitted with a 50-candle-power multiple coil stereopticon lamp which would throw a light several hundred feet ahead. This lamp consumed 4 or 5 amperes at 42 volts. It was supplemented by two headlights of 16 candle-power each, and the car was also provided with an 8-candle-power electric tail-light.

[Concluded from SUPPLEMENT No. 1618, page 25931.]

THE ART OF CUTTING METALS.*

By FRED W. TAYLOR, Philadelphia, President American Society Mechanical Engineers.

THE GAIN FROM THE SLIDE RULE GREATEST OF ALL.

WHILE many of the results of these experiments are both interesting and valuable, we regard as of by far the greatest value that portion of our experiments and of our mathematical work which has resulted in the development of the slide rules—i. e., the patient investigation and mathematical expression of the exact effect upon the cutting speed of such elements as the shape of the cutting edge of the tool, the thickness of the shaving, the depth of the cut, the quality of the metal being cut, and the duration of the cut, etc. This work enables us to fix a daily task with a definite time allowance for each workman who is running a machine tool, and to pay the men a bonus for rapid work.

The gain from these slide rules is far greater than that of all the other improvements combined, because it accomplishes the original object for which in 1880 the experiments were started—i. e., that of taking the control of the machine shop out of the hands of the many workmen and placing it completely in the hands of the management, thus superseding "rule of thumb" by scientific control.

By far the most difficult and illusive portion of this work has been the mathematical side: First, finding simple formulæ which expressed with approximate accuracy the effect of each of the numerous variables upon the cutting speed, and, second, finding a rapid method of using these formulæ in the solution of the daily machine shop problems. Several times during the progress of this mathematical work the writer, feeling himself completely baffled, has asked the expert assistance of some of the best mathematicians in the country. They all smiled when told that we expected to solve mathematically a problem containing twelve variables, and in each case, after keeping the formulæ before them for a longer or shorter time, returned the problem to the writer with the statement that it belonged distinctly in the realm of "rule of thumb" or empiricism, and could be solved only by the slow method of trial and error.

TWO TYPES OF EXPERIMENTS.

In the investigation of an art such as that of cutting metals, and about which at the time our work was started there was so little scientific knowledge, two types of experiments are possible:

First, the thoroughly scientific type, in which, after an analysis of all the variable elements which affect the final result, an attempt is made to hold all of the elements constant and uniform except the one variable which is under investigation, and this one is systematically changed and its effect upon the problem carefully noted. It is to this type that our experiments belong, thanks mainly to the fact that William Sellers (one of the most scientific experimenters of his day) was president of the Midvale Steel Company when the writer started his work.

Second, the type of experiments in which the effect of two or more variables upon the problem is investigated at the same time and in the same experiment. This method is of course much quicker than the thoroughly scientific type, and it is largely for this reason, in the opinion of the writer, that almost all of the other experimenters in this field have chosen it. Several of the experiments of this type have proved most valuable and developed much useful information, and it is with hesitancy that the writer criticises the work of any of these experimenters, since he appreciates most keenly the difficulties under which they worked, and is grateful for the information contributed by them to the art.

Almost the whole course of our experiments is marked by imperfections in our methods, which, as we have realized them, have led us to go again more carefully over the ground previously traveled. These errors may be divided into three principal classes: (a) The adoption of wrong or inadequate standards for measuring the effect of each of the variables upon the cutting speed. (b) Failure on our part from various causes to hold all of the variables constant except the one which was being systematically changed in order to study the effect of these changes upon the cutting speed. (c) The omission either through oversight or carelessness on our part of some one of the precautions which should be taken to insure accuracy, or failure to record some of the phenomena considered unimportant at the time, but which afterward proved to be essential to a complete understanding of the facts.

EFFECT OF EACH VARIABLE ON CUTTING SPEED.

The effect of each variable upon the problem is best determined by finding the exact rate of cutting speed (say, in feet per minute) which shall cause the tool to be completely ruined after having been run for 20 minutes under uniform conditions.

For example, if we wish to investigate the effect which a change in the thickness of the feed has upon the cutting speed it is necessary to make a number of tools which are in all respects uniform as to the exact shape of their cutting edge, their clearance and lip angles, the chemical composition, and their heat treatment. These tools must then be run one after another, each for a period of 20 minutes, throughout which time the cutting speed is maintained exactly uniform. Each tool should be run at a little faster cutting speed than its predecessor, until that cutting speed has been found which will cause the tool to be completely ruined at the end of 20 minutes (with an allowance of a minute or two each side of the 20-minute mark). In this way that cutting speed is found which corresponds to the particular thickness of shaving which is under investigation.

A change is then made in the thickness of the shaving and another set of 20-minute runs is made, with a series of similar uniform tools, until the cutting speed corresponding to the new thickness of feed has been determined; and by continuing in this way all of the cutting speeds are found which correspond to the various changes of feed. In the meantime every precaution must be taken to maintain uniform all the other elements or variables which affect the cutting speed, such as the depth of the cut and the quality of the metal being cut; and the rate of the cutting speed must be frequently tested during each 20-minute run to be sure that it is uniform.

The cutting speeds corresponding to varying feeds are then plotted as points upon a curve, and a mathematical expression is found which represents the law of the effect of feed upon cutting speed. We believe that this standard or method of procedure constitutes the very foundation of successful investigation in this art, and it is from this standpoint that we propose to criticise both our own experiments and those made by other investigators.

It was only after fourteen years' work that we found that the best measure for the value of a tool lay in the exact cutting speed at which it was completely ruined at the end of 20 minutes. In the meantime we had made one set of experiments after another as we successively found the errors due to our earlier standards, and realized and remedied the defects in our apparatus and methods; and we have now arrived at the interesting though rather humiliating conclusion that, with our present knowledge of methods and apparatus, it would be entirely practicable to obtain through four or five years of experimenting all of the information which we have spent twenty-six years in getting. The following are some of the more important errors made by us:

FINDING OUT WHAT TO AVOID.

We wasted much time by testing tools for a shorter cutting period than 20 minutes, and then having found that tools which were apparently uniform in all respects gave most erratic results (particularly in cutting steel) when run for a shorter period than 20 minutes, we erred in the other direction by running our tools for periods of 30 or 40 minutes each, and in this way used up in each single experiment so much of the forging that it was impossible to make enough experiments in cutting metal of uniform quality to get conclusive results. We finally settled on a run of 20 minutes as being the best all round criterion, and have seen no reason for modifying this conclusion up to date.

We next thought a proper criterion for judging the effect of a given element upon the cutting speed lay in determining the particular cutting speed which would just cause a tool to be slightly discolored below the cutting edge at the end of the 20 minutes. After wasting six months in experimenting with this as our standard we found that it was not a true measure, and then adopted as a criterion a certain definite dulling or rubbing away of the cutting edge. Later it was found, however, that each thickness of feed had corresponding to it a certain degree of dullness or injury to the cutting edge at which point regrinding was necessary (the thicker the shaving the duller the tool should be before grinding), and a third series of experiments was made with this as a standard. While experimenting on light forgings a standard dullness of tool was used which was just sufficient to push the forging and tool apart and so slightly alter the diameter of the work. All of these criterions were discarded, however, when in 1894 we finally hit upon the true standard, above described, of completely ruining the tool in 20 minutes. This standard demands both a very large and expensive machine to experiment with, and also large, heavy masses of metal to work upon, which is unfortunate; but we believe without apparatus and methods of this kind it is out of the question accurately to determine the laws which are sought. Experiments upon the art of cutting metals (at least those experiments which have been recorded) have been mainly undertaken by scientific men, mostly by professors. It is but natural that the scientific man should lean toward experiments which require the use of apparatus and that type of scientific observation which is beyond the scope of the ordinary mechanic, or even of engineers unless they have been especially trained in this kind of observation. It is perhaps for this reason more than any other that in this art several of those elements which are of the greatest importance have received no attention from experimenters, while far less fruitful, although more complicated elements have been the subject of extended experiments. As an illustration of this fact we would call attention to two of the most simple of all of the elements which have been left entirely untouched by all experimenters—namely:

a. The effect of cooling the tool through pouring a heavy stream of water upon it, which results in a gain of 40 per cent. in cutting speed.

b. The effect of the contour or outline of the cutting edge of the tool upon the cutting speed, which when properly designed results in an equally large percentage of gain.

Both of these elements can be investigated at comparatively small cost and with comparatively simple apparatus, while that element which has received chief attention from experimenters—namely, the pressure of the chip on the tool—calls for elaborate and expensive apparatus and is almost barren of useful results. This should be a warning to all men proposing to make experiments in any field, first, to look thoroughly over the whole field and at least carefully consider all of the elements from which any practical results may be expected, and then to select the more simple and elementary of these and properly investigate them before engaging in the more complicated work.

NOTABLE EXPERIMENTS BY OTHERS.

The most notable experiments in this art that have come to the writer's attention are those made at Manchester, England, during the years 1902 and 1903. All these experiments were made jointly by eight of the most prominent English manufacturing companies, among whom were Armstrong & Co., Vickers' Sons & Maxim, John Brown & Co., Thomas Firth & Sons, and others, who combined with the Manchester Association of Engineers and the Manchester Municipal School of Technology, the latter being principally represented by Dr. J. T. Nicholson, who made the final report entitled "Experiments With a Lathe Tool Dynamometer," published in Transactions, vol. 25. In 1901 a committee of the Verein Deutscher Ingenieure (Union of German Engineers), together with the managers of some of the larger engineering works in Berlin, made an interesting series of experiments which was published September 28, 1901, in the Zeitschrift des Verein Deutscher Ingenieure, and on November 15, 1905, there were published in Bulletin No. 2 of the University of Illinois, experiments made by Prof. L. P. Breckinridge and Henry B. Dirks.

The work of all these men belongs to the second type of experiments above referred to, in which the joint effect of two or more variables is studied at the same time. In the case of the Manchester experiments, the work appears to have been, to a considerable extent, a test as to the all-round knowledge in the art of cutting metals possessed by eight of the prominent English firms. These firms each presented tools made from their own tool steel, treated their own way, and ground to whatever shapes and angles the particular company considered would do the largest amount of work. Each company was allowed to have one guess on each of the qualities of metal worked upon, with each change of feed and depth of cut, as to the cutting speed at which they believed their tool would do the most work. If, under this cutting speed, the tool failed to hold out throughout the stipulated period of time, they were then given no opportunity to find the exact cutting speed at which the tool would do its best work. And, on the other hand, in those cases in which a tool did good work throughout its specified period of time no effort was made to find how much faster it could have run and still do good work. Great variety was shown in the shapes of the tools used in the experiments, yet no effort was made to definitely determine which make of tool steel or which shape of the tool was best, or even in case a tool did exceptionally good work no effort was made to determine whether this was due to the shape of the tool or to the quality and treatment of the tool steel.

DISCOVERIES MADE WHICH WERE NOT LOOKED FOR.

It is a noteworthy fact that when thorough investigations are attempted by earnest men in new fields, while frequently the object aimed at is not attained, yet quite often discoveries are made which are entirely foreign to the purpose for which the investigation was undertaken. And it may be said that the indirect results of careful scientific work are, generally speaking, fully as valuable as the direct. Two interesting illustrations of this fact have been furnished by our experiments.

* Extracts from Part I. of the President's annual address at the New York meeting (December, 1906) of the American Society of Mechanical Engineers.

The discovery of the Taylor-White process of treating tools by heating them almost to the melting point, or, in other words, the introduction of modern high speed tools the world over, was the indirect result of one of our lines of investigation. The demonstration of the fact that the rules for using belting in common practice furnished belts which were entirely too light for economy was also one of the indirect results of our experiments. The manner of making these discoveries was each time in a way so typical of what may be expected in similar cases that it would seem worth while to describe it in some detail.

During the winter of 1894-1895, the writer conducted an investigation in the shop of William Sellers & Co., at the joint expense of William Cramp & Sons, shipbuilders, and William Sellers & Co., to determine which make of self-hardening tool steel was, on the whole, the best to adopt as standard for all of the roughing tools of these two shops.

As a result of this work the choice was narrowed down at that time to two makes of tool steel: (1) the celebrated Mushet self-hardening steel, the chemical composition of the particular bar analyzed at this time showing tungsten, per cent, 5.441, chromium 0.398, carbon 2.150, manganese 1.578, silicon 1.044, no phosphorus and no sulphur; and (2) a self-hardening steel made by the Midvale Steel Company, having tungsten, per cent, 7.723, chromium 1.830, carbon 1.143, manganese 0.180, silicon 0.246, phosphorus 0.023, and sulphur 0.008.

Of these two steels the tools made from the Midvale steel were shown to be capable of running at rather higher cutting speeds. The writer himself heated hundreds of tools of these makes in the course of his experiments in order to determine accurately the best temperatures for forging and heating them prior to grinding, so as to get the best cutting speeds. In these experiments he found that the Mushet steel if overheated crumbled badly when struck even a light blow on the anvil, while the Midvale steel if overheated showed no tendency to crumble, but, on the other hand, was apparently permanently injured. In fact, heating these tools slightly beyond a bright cherry red caused them permanently to fall down in their cutting speeds, and the writer was unable at that time to find any subsequent heat treatment which would restore a tool broken down in this way to its original good condition. This defect in the Midvale tools left us in doubt as to whether the Mushet or the Midvale was, on the whole, the better to adopt as a shop standard.

HEAT TREATMENT EXPERIMENTS.

In the summer of 1898, soon after undertaking the reorganization of the management of the Bethlehem Steel Company, the writer decided to continue the experiments just referred to, with a view to ascertaining whether in the meanwhile some better tool steel had not been developed. After testing several additional makes of tools our experiments indicated that the Midvale self-hardening tools could be run, if properly heated, at slightly higher speeds than those of any other make.

Upon deciding to adopt this steel as our standard the writer had a number of tools of each make of steel carefully dressed and ground to exactly the same shape. He then called the foremen and superintendents of the machine shops of the Bethlehem Steel Company to the experimental lathe so that they could be convinced by seeing an actual trial of all of the tools that the Midvale steel was, on the whole, the best. In this test, however, the Midvale tools proved to be worse than those of any other make; i. e., they ran at slower cutting speeds. This result was rather humiliating to us as experimenters who had spent several weeks in the investigation.

It was of course the first impression of the writer that these tools had been overheated in the smith shop. Upon careful inquiry among the smiths, however, it seemed as though they had taken special pains to dress them at a low heat, although the matter was left in much doubt. The writer, therefore, determined to make a thorough investigation before finally adopting the Midvale steel as our shop standard, to discover if possible some heat treatment which would restore Midvale tools injured in their heating (whether they had been underheated or overheated) to their original good condition.

For this purpose Mr. White and the writer started a carefully laid out series of experiments, in which tools were to be heated at temperatures increasing, say, by about 50 degrees all the way from a black heat to the melting point. These tools were then to be ground and run in the experimental lathe upon a uniform forging, so as to find:

a. That heat at which the highest cutting speed could be attained (which our previous experiments had shown to be a cherry red);

b. To determine accurately the exact danger point at which if over or underheated these tools were seriously injured;

c. To find some heat treatment by which injured tools could be restored to their former high cutting speeds.

HEATING TOOLS CLOSE TO THE MELTING POINT.

These experiments corroborate our Cramp-Sellers experiments, showing that the tools were seriously broken down or injured by overheating say, somewhere between 1,500 deg. F. and 1,700 deg. F.; but to our great surprise tools heated up to or above the high heat of 1,725 deg. F. proved better than any of those heated to the best previous temperature, namely, a bright cherry red; and from 1725 deg. F. up to the incipient point of fusion of the tools, the higher they were heated the higher the cutting speeds at which they would run.

Thus, the discovery that phenomenal results could be obtained by heating tools close to the melting point, which was so completely revolutionary and directly the opposite of all previous heat treatment of tools, was the indirect result of an accurate scientific effort to investigate as to which brand of tool steel was, on the whole, the best to adopt as a shop standard, neither Mr. White nor the writer having the slightest idea that overheating beyond the bright cherry red would do anything except injure the tool more and more the higher it was heated.

HEAVY BELTS FOUND DESIRABLE.

During our early Midvale Steel Company experiments, extending from 1880 to 1883, the writer had so much trouble in maintaining the tension of the belt used in driving the boring mill upon which he was experimenting that he concluded: (1) That belting rules in common use furnished belts entirely too light for economy; and (2) that the proper way to take care of belting was to have each belt in a shop tightened at regular intervals with belt clamps especially fitted with spring balances, with which the tension of the belt was accurately weighted every time it was tightened, each belt being retightened each time to exactly the same tension.

In 1884 the writer designed and superintended the erection of a new machine shop for the Midvale Steel Company, and this gave him the opportunity to put these conclusions to a practical test. About half the belts in the shop were designed according to the ordinary rules and the other half were made about three times as heavy as the usual standard. This shop ran day and night. The belts were in all cases cared for and retightened only upon written orders sent from the shop office; and an accurate record was kept through nine years of all items of interest concerning each belt, namely, the number of hours lost through interruption to manufacture; the number of times each belt interrupted manufacture; the original cost of each belt; the detail costs of tightening, cleaning and repairing each belt; the fall in the tension before requiring retightening; and the time each belt would run without being retightened. Thus at the end of nine years these belts furnished a record which demonstrated beyond question many important facts connected with the use of belting, the principal of these being that the ordinary rules gave belts only about one-half as heavy as should be used for economy. This belting experiment illustrates again the good that often comes indirectly from experiments undertaken in an entirely different field.

SHOP MANAGEMENT.

After many years of close personal contact with our mechanics I have great confidence in their good judgment and common sense in the long run, and I am proud to number many of them among my most intimate friends. As a class, however, they are extremely conservative, and if left to themselves their progress from the older toward better methods will be exceedingly slow. And my experience is that rapid improvement can only be brought about through constant and heavy pressure from those who are over them. It must be said, therefore, that to get any great benefit from the laws derived from these experiments our slide rules must be used, and these slide rules will be of but little, if any, value under the old style of management, in which the machinist is left with the final decision as to what shape of tool, depth of cut, speed and feed he will use. The slide rules cannot be left at the lathe to be banged about by the machinist. They must be used by a man with reasonably clean hands, and at a table or desk, and this man must write his instructions as to speed, feed, depth of cut, etc., and send them to the machinist well in advance of the time that the work is to be done. Even if these written instructions are sent to the machinist, however, little attention will be paid to them unless rigid standards have been not only adopted, but enforced, throughout the shop for every detail, large and small, of the shop equipment, as well as for all shop methods. And further, but little can be accomplished with these laws unless the old style foreman and shop superintendent have been done away with and functional foremanship has been substituted—consisting of speed bosses, gang bosses, order-of-work men, inspector, time study men, etc. In fact, the correct use of slide rules involves the substitution of our whole task system of management for the old style management, as described in our paper on "Shop Management" (Transactions, vol. 24). This involves such radical, one might almost say revolutionary, changes in the mental attitude and habits, both of the workmen and of the management, and the danger from strikes is so great and the chances for failure are so many, that such a reorganization should only be undertaken under the direct control (not advice but control) of men who have had years of experience and training in introducing this system.

MACHINE SHOP OUTPUT CAN BE DOUBLED.

A long time will be required in any shop to bring about this radically new order of things; but in the end the gain is so great that I say without hesitation that there is hardly a machine shop in the country whose output cannot be doubled through the use of these methods. And this applies not only to large shops, but also to comparatively small establishments. In a company whose employees all told, including officers and salesmen, number about 150 men, we have succeeded in more than doubling the output of the shop, and in converting an annual loss of 20 per cent upon the old volume of business into an annual profit of more than 20 per cent upon the new volume of business, and at the same time rendering a lot of disorganized and dissatisfied workmen contented and hard-working, by insuring them an average increase of about 35 per cent in their wages. And I take this opportunity of again saying that those companies are indeed fortunate who can secure the services of men to direct the introduction of this type of management who have had sufficient training and experience to insure success.*

Unfortunately those fundamental ideas upon which the new task management rests mainly for success are directly antagonistic to the fundamental ideas of the old type of management. To give two out of many examples: Under our system the workman is told minutely just what he is to do and how he is to do it; and any improvement which he makes upon the orders given him is fatal to success. While, with the old style, the workman is expected constantly to improve upon his orders and former methods, under our system any improvement, large or small, once decided upon goes into immediate use and is never allowed to lapse or become obsolete, while under the old system the innovation unless it meets with the approval of the mechanic (which it never does at the start) is generally for a long time, at least, a positive impediment to success. Thus many of those elements which are mainly responsible for the success of our system are failures and a positive clog when grafted on the old system.

For this reason the really great gain which will ultimately come from the use of these slide rules will be slow in arriving—mainly, as explained, because of the revolutionary changes needed for their successful use—but it is sure to come in the end.

STANDARDIZATION MEANS SIMPLIFICATION.

Too much emphasis cannot be laid upon the fact that standardization really means simplification. It is far simpler to have in a standardized shop two makes of tool steel than to have twenty makes of tool steel, as will be found in shops under the old style of management. It is far simpler to have all of the tools in a standardized shop ground by one man to a few simple but rigidly maintained shapes than to have, as is usual in the old style shop, each machinist spend a portion of each day at the grindstone, grinding his tools with radically wrong curves and cutting angles, merely because bad shapes are easier to grind than good. Hundreds of similar illustrations could be given showing the true simplicity (not complication) which accompanies the new type of management.

There is, however, one element in which the new type of management to all outward appearance is far more complicated than the old—namely, no standards and no real system of management can be maintained without the supervision, and, what is more, the hard work of men who would be called by the old style of management supernumeraries or non-producers. The man who judges of the complication of his organization only by looking over the names of those on the payroll and separating the so-called non-producers from the producers, finds the new style of management more complicated than the old.

No one doubts for one minute that it is far simpler to run a shop with a boiler, steam engine, shafting, pulleys and belts than it would be to run the same shop with the old fashioned foot power, yet the boiler, steam engine, shafting, pulleys and belts require, as supernumeraries or non-producers on the payroll, a fireman, an engineer, an oiler, and often a man to look after belts. The old style manager, however, who judges of complication only by comparing the number of non-producers with that of the producers, would find the steam engine merely a complication in management. The same man, to be logical, would find the whole drafting force of an engineering establishment merely a complication, whereas in fact it is a great simplification over the old method.

A HUMAN MANAGING MACHINE NEEDED.

Now our whole system of management is quite accurately typified by the substitution of an elaborate engine to drive and control the shop in place of the old fashioned foot power. There is no question that our human managing machine, which is required for the maintenance and the effective use of both standard shop details and standard methods throughout the establishment, calls for many more non-producers than are used with the old style management, having its two or three foremen and a superintendent. The efficiency of our engine of management, however, compared with the old single foreman, is like a shop engine as compared with foot power, or the drafting room as compared with having the designing done by the pattern maker, blacksmith and machinist.

A study of the recommendations made throughout this paper will illustrate the fact that we propose to take all of the important decisions and planning, which vitally affect the output of the shop, out of the hands of the workmen and centralize them in a few men, each of whom is especially trained in the art of making those decisions and in seeing that they are carried out, each man having his own particular function in which he is supreme, and not interfering with the functions of other men.

INDEPENDENT MOTORS CRITICISED.

There is one recommendation, however, in modern machine shop practice, in making which the writer will probably be accused of being old fashioned or

* The writer feels free to give this advice most emphatically without danger of having his motives misinterpreted, since he has himself given up accepting professional engagements in this field.

ultra conservative. Of late years there has been what may be almost termed a blind rush on the part of those who have wished to increase the efficiency of their shops toward driving each individual machine with an independent motor. The writer is firmly convinced through large personal observation in many shops and through having himself systematized two electrical works that in perhaps three cases out of four a properly designed belt drive is preferable to the individual motor drive for machine tools. There is no question that through a term of years the total cost, on the one hand, of individual motors and electrical wiring, coupled with the maintenance and repairs of this system, will far exceed the first cost of properly designed shafting and belting plus maintenance and repairs (in most shops entirely too light belts and countershafts of inferior design are used, and the belts are not systematically cared for by one trained man, and this involves a heavy cost for maintenance).

It is at last admitted that there is little, if any, economy in power obtainable through promiscuous motor driving, and it will certainly be found to be a safe rule not to adopt an individual motor for driving any machine tool unless clearly evident that a large saving can be made by it.

AN ERA OF TRUE CO-OPERATION.

In concluding let me say that we are now but on the threshold of the coming era of true co-operation. The time is fast going by for the great personal or individual achievement of any one man standing alone and without the help of those around him. And the time is coming when all great things will be done by the co-operation of many men, in which each man performs that function for which he is best suited, each man preserves his own individuality and is supreme in his particular function and each man at the same time loses none of his originality and proper personal initiative, and yet is controlled by and must work harmoniously with many men.

And let me point out that the most important lessons taught by these experiments, particularly to the younger men, are: Several men when heartily co-operating, even if of everyday caliber, can accomplish what would be next to impossible for any one man, even of exceptional ability. Expensive experiments can be successfully carried on by men without money, and the most difficult mathematical problems can be solved by very ordinary mathematicians, providing only that they are willing to pay the price in time, patience and hard work. The old adage is again made good, that all things come to him who waits, if only he works hard enough in the meantime.

SCIENTIFIC ASPECTS OF LUTHER BURBANK'S WORK.*

By VERNON L. KELLOGG, Professor of Entomology, Stanford University.

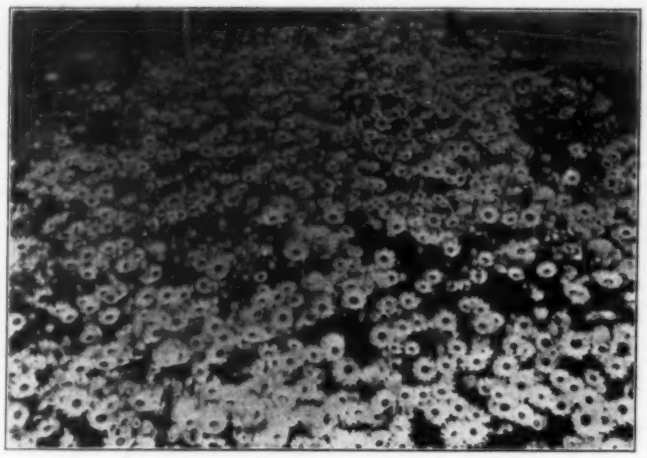
MR. BURBANK has so far not formulated any new or additional laws of species-change, nor do his observations and results justify any such formulation, and we may rest in the belief that he has no new fundamental laws to reveal. He has indeed the right to formulate, if he cares to, some valuable and significant special conclusions touching certain already recognized evolution factors, in particular, the influence on variability of the two long-known variation-producing factors of hybridization and modification of environment. His reliance on the marked increase in variability to be got after a crossing in the second and third generations over that obvious in the first will come as a surprise to most men first getting acquainted with his work. He has got more starts for his new things from these generations than in any other way. He is wholly clear and convinced in his own mind as to the inheritance of acquired characters; "acquired characters are inherited or I know nothing of plant life," he says; and also convinced that the only unit in organic nature is the individual, not the species; that the so-called species are wholly mutable and dependent for their apparent fixity solely on the length of time through which their so-called phyletic characters have been ontogenetically repeated. He does not agree at all with De Vries that mutations in plants occur only at certain periodic times in the history of the species, but rather that if they occur at all, they do so whenever the special stimulus derived from unusual nutrition or general environment can be brought to bear on them. He finds in his breeding work no prepotency of either sex as such in inheritance, though any character or group of characters may be prepotent in either sex. He believes that no sharp line can be drawn between the fluctuating or so-called Darwinian variations and those less usual, large, discontinuous ones called sports. Ordinary fluctuating variation goes on under ordinary conditions of nutrition, but with extraordinary environmental conditions come about extraordinary variation results, namely, discontinuous, sport or mutational variation. These variations are the effects of past environment also, having remained latent until opportunity for their development occurs. Starvation causes reversions, but reversions can also be produced by unusually rich nutrition. New variations are developed most often, as far as environmental influences go, by rich soil and generally favorable conditions. So-called *new* qualities are usually, if not always (the fact may sometimes not be obvious), simply new combinations of old qualities, both latent and obvious. To get a new and pleasing odor it may often be sufficient simply to lose one bad element in an old odor. So one might go on for some pages with specific conclusions or deductions reached by Burbank on a basis of experience. But it is true that he has at his command the knowledge of no new fundamental scientific principles to give him advantage over us. And yet none of us has done what Burbank has been able to do, although many of us have tried. What then is it that Burbank brings to his work of modifying organisms swiftly and extremely and definitely that others do not?

To answer this it will be advisable to analyze, in general terms, at least, the various processes which either singly, or in combinations of two or three, or all together, are used by Mr. Burbank in his work. We may roughly classify these processes and means. First, there is the importation from foreign countries, through many correspondents, of a host of various kinds of plants, some of economic value in their native land and some not, any of which grown under different conditions here may prove specially vigorous or prolific or hardy, or show other desirable changes or new qualities. Among these importations are often special kinds particularly sought for by Burbank to use in his multiple hybridizations; kinds closely related to our native or to already cultivated races which, despite many worthless characteristics, may possess one or more particular, valuable ones needed to be added to a race already useful to make it more useful. Such an addition makes a new race.

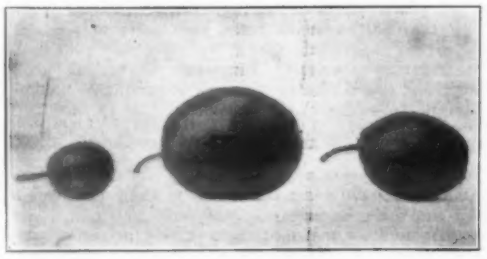
Second, the production of variations, abundant and extreme, by various methods, as (*a*) the growing under new and, usually, more favorable environment (food supply, water, temperature, light, space, etc.) of various wild or cultivated forms, and (*b*) by hybridizations between forms closely related, less closely related and, finally, as dissimilar as may be (not producing sterility), this hybridizing being often immensely complicated by multiplying crosses, i. e., the offspring from one cross being immediately crossed with a third form, and the offspring of this with still another form, and so on. These hybridizations are made sometimes with very little reference to the actual useful or non-useful characteristics of the crossed parents, with the primary intention of producing an unsettling or instability in the heredity, of causing, as Burbank sometimes says, "perturbations" in the plants, so as to get just as wide and as large variation as possible. Other crosses are made, of course, in the deliberate attempt to blend, to mix, to add together, two desirable characteristics, each possessed by only one of the crossed forms. Some crosses are made in the attempt to extinguish an undesirable characteristic.

Third, there is always immediately following the unusual production of variations, the recognition of desirable modifications and the intelligent and effective selection of them, i. e., the saving of those plants to produce seed or cuttings which show the desirable variations and the discarding of all the others. In Burbank's gardens the few tenderly cared for little potted plants or carefully grafted seedlings represent the surviving fittest, and the great bonfires of scores of thousands of uprooted others, the unfit, in this close mimicry of Darwin and Spencer's struggle and survival in nature.

It is precisely in this double process of the recognition and selection of desirable variations that Burbank's genius comes into particular play. Right here he brings something to bear on his work that few other men have been able to do. It is the extraordinary keenness of perception, the delicacy of recognition of desirable variations in their (usually) small and to most men imperceptible beginnings. Is it a fragrance that is sought? To Burbank in a bed of hundreds of seedling walnuts scores of the odors of the plant kingdom are arising and mingling from the fresh green leaves, but each, mind you, from a certain single seedling, or perhaps from a similar pair or trio. But to me or to you, until the master prover points out two or three of the more dominant single odors, the impression on the olfactories is simply (or confusedly) that of one soft elusive fragrance of fresh green leaves. Similarly Burbank is a master at seeing, and a master at feeling. And besides he has his own unique knowledge of correlations. Does this plum seedling with its score of leaves on its thin stem have those leaves infinitesimally plumper, smoother or stronger, or with more even margins and stronger petiole or what not else, than any other among a thousand similar childish trees? Then it is saved, for it will bear a larger, or a sweeter, or a firmer sort of plum, or more plums than the others. So to the bonfires with the others and to the company of the elect



RHODANTHE NAGLESI, IMPROVED IN SIZE AND COLOR BY SELECTION ONLY.



ONE OF THE STONELESS PLUMS (CENTER) AND TWO OF ITS PARENTS.

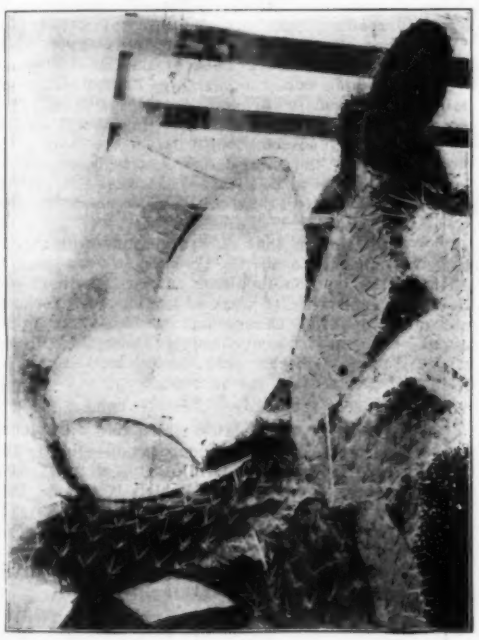
On the right hand the common French prune.

CALIFORNIA POPPY (ESCHOLTZIA) RENDERED BRIGHT CRIMSON AS A RESULT OF SELECTION ONLY, WITHOUT CROSSING.

* From the Popular Science Monthly.

with this "fittest" one. Now this recognition, this knowledge of correlations in plant structure, born of the exercise of a genius for perceiving through thirty years of opportunity for testing and perfecting it, is perhaps the most important single thing which Burbank brings to his work that other men do not (at least in such unusual degree of reliability). Enormous industry, utter concentration, and single-mindedness, deftness in manipulation, fertility in practical resource, has Burbank—and so have numerous other breeders and experimenters. But in his perception of variability in its forming, his recognition of its possibilities of outcome, and in his scientific knowledge of correlations, a knowledge that is real, for it is one that is relied on and built on, and is at the very foundation of his success, Burbank has an advantage of true scientific character over his fellow workers, and in it he makes a genuine contribution to scientific knowledge of plant biology, albeit this knowledge is so far only proved to be attainable and to exist. It is not yet exposed in its details and may never be, however unselfish be the owner of it. For the going to oblivion of scientific data of an extent and value equivalent, I may estimate roughly, to those now issuing from any half dozen experimental laboratories of variation and heredity, is the crying regret of all evolution students acquainted with the situation. The recently assumed relations of Mr. Burbank to the Carnegie Institution are our present chief hope for at least a lessening of this loss.

But let us follow our saved plum seedling. Have we now to wait the six or seven years before a plum tree comes into bearing to know by actual seeing and testing what new sort of plum we have? No; and here again is one of Burbank's contributions (not wholly original to be sure, but original in the extent and perfection of its development) to the scientific aspects of



HYBRID OPUNTIA, WITHOUT THORNS OR BRISTLES.

With a parent from which these appendages are to be removed by crossing and selection.

plant-breeding. This saved seedling and other similar saved ones (for from the examination of 20,000 seedlings, say, Burbank will find a few tens or even scores in which he has faith of reward) will be taken from their plots and grafted on to the sturdy branches of some full-grown vigorous plum tree, so that in the next season or second next our seedling stem will bear its flowers and fruits. Here are years saved. Twenty, forty, sixty, different seedlings grafted on to one strong tree (in a particular instance Burbank had 600 plum grafts on a single tree!); and each seedling-stem certain to bear its own kind of leaf and flower and fruit. For we have long known that the scion is not materially influenced by the stock nor the stock by the scion; that it is not modified radically, although grafting sometimes increases or otherwise modifies the vigor of growth and the extent of the root system of the stock.

If now the fruit from our variant seedling is sufficiently desirable; if it produces earlier or later, sweeter or larger, firmer or more abundant, plums, we have a new race of plums, a "new creation" to go into that thin catalogue of results. For by simply subdividing the wood of the new branch, i. e., making new grafts from it, the new plum can be perpetuated and increased at will. Simple, is it not? No, it is anything but that in the reality of doing it; but in the scientific aspects of it, easily understandable.

Perhaps it may not be amiss to call attention to what must be the familiar knowledge of most of us, and that is the fact that many (probably most) cultivated plants must be reproduced by division, that is by cuttings, buds, or grafts, and not by seeds, in order to grow "true." For a piece of a cultivated plant will grow out to be very much like the individual it was cut from, but the seeds will not, in most cases, reproduce faithfully the parents, but will produce a very variable lot of individuals, most of them strongly reversionary in character. Grow peach trees from the stones of your favorite peach and see what manner of peaches you get; but if you want to be sure of more peaches like the ones you enjoy, graft scions from your tree onto other trees. Indeed one of the plant-breeder's favorite methods of making a start for new

EARLY AND ABUNDANT BEARING CHESTNUT TREE.

One of hundreds of similar ones, due to crossing and selection. These bear fruit at the age of one and a half years and are never without fruit.

things, of getting the requisite beginning wealth and eccentricity of variation, is to grow seedlings, especially from cross-bred varieties. Burbank will give you a thousand dollars for a pinch of horse-radish seed. Sugar-cane seed is needed. The amelioration of many kinds of fruit and flowers and vegetables is checked, because in our carelessness we have allowed these kinds to get into that condition of seedlessness which almost all cultivated races tend toward when grown from cuttings. In our oranges and grape-fruit and in a score of other fruits, the elimination of seeds is exactly one of the modifications we have bred and selected for, in order to make the fruits less troublesome in their eating. But when we lose the seeds entirely of a whole group of related plant kinds we may find ourselves, as we have found ourselves actually in many cases, at the end of our powers of amelioration of these plant sorts. Burbank believes that the very fact that plants when grown asexually always sooner or later lose their power to produce seeds is almost sufficient proof (if such proof is needed) that acquired characters are transmitted.

Another of Burbank's open secrets of success is the great range of his experimentation—nothing is too bold for him to attempt, the chances of failure are never too great to frighten him. And another secret is the great extent, as regards material used, of each experiment. His beds of seedlings contain hundreds, often thousands, of individuals where other men are content with hundreds. Another element in his work is his prodigality of time. Experiments begun twenty years ago are actually still under way.

In all that I have so far written, I have purposely kept to general statements applicable to Burbank's work as a whole. My readers might be more interested, perhaps, to have some illustrations of the application of various processes of making new sorts of things, some analytical account of the history of various specific "new creations," but considerations of space practically forbid this. Just a few briefly described examples must suffice. More than is generally imagined, perhaps, Burbank uses pure selection to get new things. From the famous golden orange colored California poppy (*Escholtzia*) he has produced a fixed new crimson form by selection alone. That is, noticing, somewhere, sometime, an Escholtzia individual varying slightly redder, he promptly took possession of it, raised young poppies from its seeds, selected from among them those varying in a similar direction, raised new generations from them and so on until now he who wishes may have his California poppies of a strange glowing crimson for the price of a little package of seed, where formerly he was perforce content with the golden orange. For me the golden orange suffices, but that does not detract from my eager interest in the flower-painting methods of Mr. Burbank. Even more striking a result is his blue Shirley poppy, produced also solely by repeated selection from the crimson field poppy of Europe. "We have long had various shades of black and crimson and white poppies, but no shade of blue. Out of 200,000 seedlings I found one showing a faintest trace of sky blue, and planted the seed from it, and got next year one pretty blue one out of many thousand, and now I have one almost pure blue."

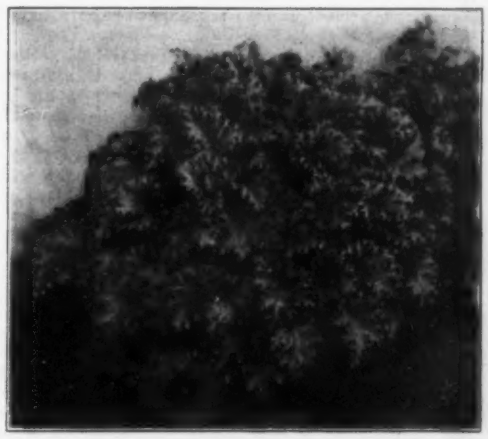
But another brilliant new poppy was made in a different way. The pollen of *Papaver pilosum*, a butter-colored poppy, was put on the pistils of the Bride, a common pure white variety of *Papaver somniferum* (double), and in the progeny of this cross was got a fire-colored single form. The character of singleness was common to the ancestors of both parents, the character of fire color in the lineage of *somniferum* only, although the red of the new form is brighter than ever before known in the somnifera series. Both characteristics were absent (or rather latent) in both parents. And yet the perturbing influence of the hybridization brought to the fore again these ancestral characters. The foliage of this fire poppy is intermediate in type between that of the two parents.

The history of the stoneless and seedless plum, now being slowly developed by Burbank, shows an interesting combination of selection, hybridization, and reselecting. Mr. Burbank found a plum in a small wild plum species with only a part of a stone. He crossed this wild species with the French prune; in the first generation he got most individuals with whole stones, some with parts of a stone, and even some with no stone. Through three generations he has now carried his line by steadily selecting, and the percentage of no-stone fruits is slowly increasing, while quality, beauty and productiveness are also increasing at the same time.

The plum-cot is the result of crossing the Japanese plum and the apricot. The plum-cot, however, has not yet become a fixed variety, and may never be, as it tends to revert to the plum and apricot about equally, although with also a tendency to remain fixed, which tendency may be made permanent.

Most of Burbank's plums and prunes are the result of multiple crossings in which the Japanese plums have played an important part. Hundreds of thousands of seedlings have been grown and carefully worked over in the twenty years of experimenting with plums, and single trees have been made to carry as many as 600 varying seedling grafts. The Bartlett plum, cross of the bitter Chinese Simoni and the Delaware, itself a Simoni hybrid, has the exact fragrance and flavor of the Bartlett pear. The Climax, a successful shipping plum, is also a cross of the Simoni and the Japanese triflora. This Chinese Simoni produces almost no pollen, but few grains of it ever having been obtained. But these few grains have enabled Burbank to revolutionize the whole plum shipping industry. The sugar prune, which promises to supplant the French prune in California, is a selected product of a second or third generation variety of the Petite d'Agen, a somewhat variable French plum.

Next in extent probably to Burbank's work with plums and prunes is his long and successful experimentation with berries. This has extended through twenty-five years of constant attention, has involved the use, in hybridizations, of forty different species of *Rubus*, and has resulted in the origination of a score of new commercial varieties, mostly obtained through various hybridizations of dewberries, blackberries, and



HEUCHERA LEAVES MADE CRESTED BY SELECTION OF VARYING SEEDLINGS.

raspberries. Among these may specially be mentioned the Primus, a hybrid of the western dewberry (*R. ursinus*) and the Siberian raspberry (*R. crataegifolius*), fixed in the first generation, which ripens its main crop before most of the standard varieties of raspberries and blackberries commence to bloom. (Mr. Burbank does not recommend this for general cultivation; the "Phenomenal" and Himalaya are better.) In this Primus berry, we have the exceptional in-

stance of a strong variation, due to hybridization, breeding true from the time of its first appearance. It usually takes about six generations to fix a new variety, but like De Vries's evening primrose mutations, the Primus berry is a fixed new form from the time of its beginning. An interesting feature of Mr. Burbank's brief account, in his "New Creations" catalogue of 1894, of the berry experimentation, is a reproduction of a photograph showing "a sample pile of brush 12 feet wide, 14 feet high, and 22 feet long, containing 65,000 two- and three-year-old seedling berry bushes (40,000 blackberry × raspberry hybrids and 25,000 Shaffer × Gregg hybrids) all dug up with their crop of ripening berries." The photograph is introduced to give the reader some idea of the work necessary to produce a satisfactory new race of berries. "Of the 40,000 blackberry × raspberry hybrids of this kind 'Phenomenal' is the only one now in existence. From the other 25,000 hybrids, two dozen bushes were reserved for further trial."

An astonishing result of the hybridization between the black walnut, *Juglans nigra*, used as the pistillate parent, and the California walnut, *J. californica*, staminate parent, are walnut trees which grow with such an amazing vigor and rapidity that they increase in size at least twice as fast as the combined growth of both parents. Many tremendous growers are got in the first generation, but in the second there are included some of the most rapidly growing trees, perhaps, in the world. This hybrid has clean-cut, glossy bright green leaves from two to three feet long with a sweet odor like that of apples, but it produces few nuts. Curiously enough the result of hybridization by using the pollen of *nigra* on pistils of *californica* produces in abundance large nuts of a quality superior to that possessed by either parent.

The famous Shasta daisy is the result of a multiple crossing between an American and a European species of field daisy and then between these hybrids and a Japanese form. The fragrant calla, known as "Fragrance," is descended from a single individual found by Burbank while critically examining a block of Little Gem calla seedlings. He was surprised in this examination by a fragrance resembling that of violets or water-lilies; as he had long been seeking a fragrant calla, the individual giving this perfume was carefully hunted out. No farther selecting was done; this plant was the single ancestor of the fragrant new race.

And so one might go on for pages, but with slight variations in detail all these pages would tell only the same story: the stimulating or inducing of variability by environmental influences and by hybridizations; the search after, and keen recognition of, promising special variations; the selection of the plants showing these variations; rearing new generations from them, repeated selection, and new hybridizations to eliminate this characteristic or introduce that, and on until a desirable combination is found. Then the careful fixing of this form or type by repeated selection through several generations.

But an end must be made of this. Let us, in a paragraph, simply sum up the essential things in the scientific aspects of Burbank's work. No new revelations to science of an overturning character; but the revelation of the possibilities of accomplishment, based on general principles already known, by an unusual man. No new laws of evolution, but new facts, new data, new canons for special cases. No new principle or process to substitute for selection, but a new proof of the possibilities of the effectiveness of the old principle. No new categories of variations, but an illuminating demonstration of the possibilities of stimulating variability and of the reality of this general variability as the fundamental transforming factor. No new evidence either to help the Darwinian factors to their death-bed, or to strengthen their lease on life; for the "man" factor in all the selecting phenomena in Burbank's gardens excludes all "natural" factors. Here are some of Burbank's own words, touching these matters that scientific men are particularly interested in, in his work:

"All scientists have found that preconceived notions, dogmas, and all personal prejudice must be set aside, listening patiently, quietly, and reverently to the lessons one by one which Mother Nature has to teach, shedding light on that which before was a mystery, so that all who will may see and know.

"Crossing gives the raiser of new plants the only means of uniting the best qualities of each, but just as often the worst qualities of each are combined and transmitted, so that to be of any value it must be followed by rigid and persistent selection, and in crossing, as in budding and grafting, the affinities can only be demonstrated by actual test.

"All wild plants of any species are under almost identical environments, having their energies taxed to the utmost in the fierce struggle for existence. Any great variation under such circumstances is not likely to occur, and is much more likely to be stamped out at once by its struggling competitors, unless the variation should be of special use in competition, in which case it will survive, and all others may be supplanted by it. Thus we see how new species are often produced by nature, but this is not her only mode. Crosses and hybrids are very often found growing wild where two somewhat similar species grow contiguous, and if the combination happens to be a useful one, as it often does, the new creation is encouraged by nature; then time and environment fix it, and man comes on the scene, perhaps ages later, and discovers it, and, not knowing all the facts, wonders where the connecting links have gone. It is botanically classified as a new species, which it is most certainly.

"In cultivated plants the life struggle is removed, and here we find variation almost the rule rather than the exception.

"Varieties are the product of fixed laws, never of chance, and with a knowledge of these laws we can improve the products of nature, by employing nature's forces, in ameliorating old or producing new species and varieties better adapted to our necessities and tastes. Better food, more sunshine, less arduous competition, will of themselves induce variation in individual plants which will be more or less transmitted to their seedlings, which, selected consecutively through a certain number of generations, will become permanent. Environment here exerts an influence as in all chemical cosmical and celestial movements. These small increments from environmental forces may produce a gradual or sudden change according to circumstances. The combustion of food liberates the moving force, environment guides it as it does the planets.

"When once the persistent type is broken up, old latent forces may be liberated and types buried in the dim past reappear. This, called atavism, is a concentration of ancestral forces—reverberating echoes—from varieties long since passed away, exhibiting themselves when from some cause, for instance crossing, present forces are in a state of antagonism, division, perturbation or weakness. These echoes, if collected by crossing and selection, produce combinations of superlative importance and value."

Finally, in any summation of the scientific aspects of Burbank's work must be mentioned the hosts of immensely valuable data regarding the inheritance of characteristics, the influence of epigenetic factors in development, the possibilities of plant variability, and what not else important to evolution students, mostly going unrecorded, except as they are added in mass to the already too heavy burden carried by the master of the laboratory, and as they are summed up in those actual results which the world gratefully knows as Burbank's "new creations."

BRITTLENESS OF MILD STEEL.

DURING the past year or two, the confidence placed by the engineering world in mild steel has been shaken by a few failures, for which as yet no satisfactory explanations have been found; but, says C. E. Stromeyer, C.E., in his recent report to the Manchester Steam Users' Association, of which he is chief engineer, of which report the following is an abstract, inquiries have been set on foot, of which it is hoped that if they do not throw any light on the true cause they may at least point to some test which will discover the doubtful material before it gets into the hands of the boiler maker.

Some interesting cases were dealt with in a report by Prof. Arnold, read before the Institution of Naval Architects, and several similar ones have recently come under my immediate notice.

When at the end of the seventies, mild qualities of steel were first made in the open-hearth furnace, it was hoped that a more reliable substitute had been found for iron than Bessemer steel could claim to be; and, after a short experience, especially on war vessels, the French and English admiralties, followed by Lloyd's Register, fixed on certain quality tests, which, so it was hoped, would discriminate between reliable and unreliable steel, or rather between open-hearth and converter steel.

In those days the chief cause of unreliability was believed to be the unequal distribution of carbon in Bessemer steel, and the most effective conditions for excluding this steel were that the material should have a high tenacity, say 25 tons and upward; a good elongation, say above 20 per cent, and the material should show no sign of brittleness after being heated to a bright-red heat and plunged into water of 28 deg. C. or 82 deg. F. By this means the use of the somewhat uncertain Bessemer steel was practically stopped for ship and boiler plates; but in spite of careful testing, iron never having been tested to the same extent, alarming failures were still experienced. The best-known of these was the breaking of the shell plates of the boilers intended for the imperial Russian yacht "Livadia." It will be remembered that after some of her boilers had been built, one of them burst while being tested, and others were found to be fractured before testing, and these plates, which had stood the workshop practice, broke when being taken to pieces. The nature of the process by which the steel was made was not divulged, but that it led to irregular distribution of constituents was evident from the analyses.

Shortly after this failure Mr. Maginnis published in The Engineer, of December, 1885, details about the failure of some other marine boilers which had been at work for 2½ years. He says:

(1) The material used for two different sets of boilers, each set consisting of three circular boilers with horizontal steam chests, passed all tests required by the Board of Trade and Lloyd's. (2) The material stood without the slightest defect the ordinary work of the boiler shop, including welding, etc. (3) Each set of boilers worked satisfactorily at sea for a period of 2½ years, after which they exhibited signs that a complete change had taken place in the nature of the steel.

Apparently the boiler plates had become absolutely brittle. The tenacities of the original plates varied from 26¼ to 30¼ tons, with elongations of from 19¾ to 27 per cent. The tensile tests of plates cut from the fractured combustion chambers showed tenacities of 25, 26, and 45 tons, with elongations up to 27 per cent for the first two, and up to 15 per cent for the hard plate.

The chemical analysis of the cracked combustion plates were as follows:

Carbon.	Silicon.	Sulphur.	Phosphorus.	Manganese.
0.125	0.005	0.051	0.060	0.320
0.175	0.018	0.045	0.068	0.350
0.125	0.018	0.043	0.051	0.530

The steel had been made by the Bessemer process, which cannot, like the open-hearth process, be relied upon to produce material of exactly the composition aimed at. Apparently, a few hard plates had not been detected by the mechanical tests at the steel works, but all showed themselves to be sufficiently ductile during construction to withstand the rough usage in the boiler shop, some at least grew perfectly brittle during the subsequent period.

When about the time of these failures I discovered that mild steel could be made permanently brittle by merely heating it to a temperature of melting lead and bending or hammering it, hopes were entertained that similar failures could now be explained, but there are evidently other causes than working steel at a blue heat which will produce brittleness, and one which was very early recognized was the presence of phosphorus in the steel in excess, of, say, 0.07 per cent.

A notable case of three ships being built of this quality of steel soon drew renewed attention to the danger of using it. Two of these ships were launched and went to sea; but fractures of their beams and angle irons were so frequent that an inquiry was made into the condition of the third ship which was still on the stocks. It was found that nearly every frame and beam could be broken by heavy blows of a hammer and that, too, in spite of the fact that these parts had shown no signs of brittleness when new, lending themselves to bending, punching, drilling, hammering, and riveting operations without either breaking or cracking. This steel had been made by the basic Bessemer converter, which once more showed that it could not be depended upon to turn out reliable material. If it were brittle immediately after rolling and shearing, such material would be thrown out before leaving the steel works, but the chief danger has to be sought for in what I believe to be a fact—that this, and perhaps other, classes of steel possess the objectionable quality of deteriorating during periods of rest.

It is well known that elastic sulphur will after a time change into a brittle crystalline form, and in Sheffield the opinion is almost universally held that their steel improves by years of keeping. Why should not other qualities change and perhaps deteriorate? At any rate, my subsequent experiences have tended strongly to confirm this view, and quite recently the following case revived the question.

BRITTLENESS DUE TO PHOSPHORUS.

One of a set of steel plates which had all satisfactorily withstood the tensile, temper, and cold bending tests cracked in two places while being slowly bent to the curvature of the shell of which it was to form part. The test samples had been bent to a radius of say, 1¼ inch without fracture, but two weeks later the same material cracked when bent to a radius of about twenty to thirty feet. The material was analyzed with the following result:

Carbon	0.150 per cent
Silicon	0.011 per cent
Sulphur	0.032 per cent
Phosphorus	0.162 per cent
Manganese	0.540 per cent
Copper	....
Arsenic	0.023 per cent

It will be seen that the phosphorus is very high, and it was discovered that this was due to a load of phosphoric pig having been charged into the acid furnace instead of the basic one. Of course, in the acid furnace no reduction of phosphorus takes place. The mechanical tests which were carried out with this steel after failure revealed nothing abnormal in its condition, but a microscopic examination gave indications that an excess of phosphorus was present. It is yet too early, however, to depend upon what is seen in the microscope, for this very steel, although its sulphur is low, contains a comparatively large number of dove-colored patches, which are generally supposed to consist of sulphide of manganese. The view at present held about phosphorus in steel is that it can exist in two allotropic forms, of which one is harmless, the other brittle. Possibly a change of condition, which may be produced by time alone, produces the change of quality which have led to these remarks.

HEAT TREATMENT OF STEEL.

Another cause of brittleness is believed to be improper heat treatment. The general opinion is, that this brittleness can be removed by renewed judicious heating, especially if accompanied by hammering or rolling, from which it would follow that the last heating process to which a piece of steel is subjected would have an all-important effect. Others seem to hold that every heat treatment through which a piece of steel passes leaves its marks. According to this view the temperature at which a charge is cast should influence its qualities. This is in a measure confirmed by differences of tenacity of steels of the same chemical composition, but made at different works, and also by the great difference of quality between the purest wrought iron and the purest steels. The former material has never been heated above a welding temperature, the latter has been in a molten condition. If this

view is correct then even the temperature of the furnace used for reheating before rolling should affect the quality of the finished article. This may have been the cause of a recent failure of another plate.

Like the previously mentioned one, it had been satisfactorily tested at the steel works, and being intended for butt straps it was being sheared again at the boiler works, when, to the surprise of everyone, these strips broke and fell off in bits.

All the plates from the same cast were at once rejected, but no tests to which they were then subjected, nor yet the chemical analysis, which was as under, revealed anything wrong, for both the phosphorus and the sulphur are low:

Carbon	0.175 per cent
Silicon	0.011 per cent
Sulphur	0.030 per cent
Phosphorus	0.059 per cent
Manganese	0.560 per cent
Copper	0.069 per cent
Arsenic	0.039 per cent
Tin	0.009 per cent

The defective plate behaved very unreasonably. As already mentioned, the strips which were sheared off in the boiler yard fell to pieces, but those sheared off subsequently at the steel works were perfectly ductile and could be bent as close as any other samples. These latter samples had been sheared off at the same end as the rest, and the shearing edge was comparatively new; when strips were sheared off the other edges which had not been touched since the plates left the steel works, these, too, were found to be brittle. Evidently, then, the injury done to the extreme edge by shearing was slowly spreading into this plate, but the shears were not to blame, for the other plates were good. There was evidently something in the quality of this steel which made it sensitive to this severe treatment, and unquestionably, therefore, it was not a suitable material to use; but how it acquired this peculiar quality was not discovered.

Possibly the slab from which the plate was rolled had been in the rolling mill furnace for two heats instead of one; but if that was so, the men who were responsible for the blunder could not be expected to admit it.

In view of the possibility of these occurrences this association may be congratulated on its system of check testing which seems to be specially adapted for detecting changes which may be slowly progressing. When a boiler is being built under our inspection, check tests are made with samples cut from certain plates, and these should, of course, reveal whether the material has grown brittle since it left the steel works. Check tests applied to the plates of Maginnis's boilers, or to the angles of the brittle ships previously referred to would, it is fairly safe to say, have revealed that a change for the worse was taking place.

TIME EFFECT ON STEEL.

A case of great interest, but one about which full details unfortunately cannot be obtained, occurred about two years ago in Russia. Some Lancashire boilers had been at work for six years, and were annually tested by hydraulic pressure in accordance with government regulations. On the occasion of the sixth test one boiler burst, and one year later the adjoining boiler burst. The analysis of the steel of the first boiler plate is given below. The two German results are duplicate determinations of the same sample. The English analysis was carried out on a sample recently received by me, but it is not certain that this is the same plate as the above.

	English Analysis. Per cent.	German Analysis. Per cent.	
Carbon	0.070	0.121	0.116
Silicon	trace	0.007	0.009
Sulphur	0.072	0.098	0.104
Phosphorus	0.063	0.065	0.070
Manganese	0.457	0.439	0.435
Copper	0.092	....	....
Arsenic	0.037	....	....

Although this material is not of first-class quality, one would hardly expect brittleness with a percentage of 0.121 per cent carbon and 0.07 per cent phosphorus; on the contrary, the analysis would lead one to expect the results which were actually obtained.

Mean tenacity 23.0 tons, elongation 28 per cent in 8 inches.

A microscopic examination of this steel indicates a low percentage of carbon; but pearlite, although scarce, occurs in very large patches, which is held to indicate that the plates had been hot and cooled slowly. After annealing the large patches break up into a large number of very small ones, and the microscopic view would seem to indicate that the material has been made ductile and mild.

SEGREGATION IN STEEL.

Engineers have frequently been puzzled by laminations in steel plates which sometimes become visible on planing, and always showed up in samples which are subjected to tension stresses and clearly revealed by etching, notably if a solution of from five to ten per cent of copper sulphate of ammonia is used. Under the microscope these layers are found to consist of numerous patches of pearlite whose structure indicates an excess of phosphorus As these layers are generally near the centers of plates they are undoubtedly due to segregation, and one would expect to find the worst cases in those works where very large ingots are cast. Strange to say, that is not the case, nearly all the samples in which the segregation was detected coming from works in which the ingot molds were selected to suit the sizes of the plates to be rolled.

An analysis made of one of these plates gave the following result:

	Central layer about 0.10 inch thick.	Two outer layers each 0.3 in. thick.
Carbon	0.305	0.160
Sulphur	0.145	0.036
Phosphorus	0.190	0.088
Manganese	0.648	0.486

There are indications which are confirmed by this analysis, that a comparatively high percentage of phosphorus encourages segregation; at any rate all those samples in which segregations were marked have contained about 0.07 per cent of phosphorus.

GROOVING AND CRACKING OF BOILER PLATES.

Another class of fractures which may possibly be influenced by the chemical composition of the material and by improper heat treatment is excessive and repeated straining, generally called fatigue. Plates which have been flanged round their edges and laid aside, sometimes crack when the circumferences have cooled. Thick forgings sometimes crack while being machined, and an armor plate once broke in two, evidently due to a similar cause. These, or somewhat similar results are produced in boiler end plates and furnace flanges due to excessive heating of the furnace plates brought about in most cases by grease in the feed and sometimes by scale. This trouble was not serious as long as boiler pressures were low and boiler plates thin and elastic, but the increased pressures demand increased strength which, if the design is not altered, is accompanied by increased rigidity and liability to fracture.

THE COMPARATIVE ECONOMY OF VARIOUS METHODS OF ILLUMINATION.

THE great improvements in illumination that have been made during the past thirty years have resulted in increased economy of material and energy, as well as increased luminosity. The public is often deceived by quotations of the cost per candle-power as a measure of the excellence of a particular lamp. The results of tests made by men of repute are given without the explanation that some of the figures refer to the sphere, some to the hemisphere, and that globes and reflectors were used in some cases and not in others. A comparison of the cost of light from various sources is possible only with certain restrictions, as the conditions and the requirements vary with the lamp. Besides, the technical efficiency is not a direct measure of the cost. A given quantity of energy, for example, costs much more at present if it is obtained from electricity than if it is furnished by petroleum or gas, but this factor is superficial, not essential, and it may and does change from day to day.

Next to the kerosene lamp, the incandescent gas lamp is at present the cheapest source of light, and it has triumphed over most unfavorable conditions, in the contest between gas and electricity. The prophecy that gas would soon be supplanted by electricity has not been fulfilled. The rivalry is still intense, and this struggle for existence leads to progress. The advocates of gas may take courage from the increase in the annual consumption of gas from 40 million cubic meters (1,400 million cubic feet) in 1859 to 800 million cubic meters (28,000 million cubic feet) at present.

The acetylene light is next in brilliancy and beauty to the electric arc, and it is cheaper than the incandescent electric light, but it cannot yet compete with kerosene or the incandescent gas light.

The incandescent electric light is used to a very great extent despite its high cost—a proof that there is a great demand for small electric lights for interior illumination. As the gas experts endeavored to supplant the electric arc by compressed gas and other devices, so have electricians and chemists, including the inventor of the incandescent gas lamp, endeavored to construct more economical types of the incandescent electric lamp.

But none of the new lamps has been able to supplant the carbon filament, wasteful of current though the latter is. The Nernst lamp, on which the greatest hopes were based, because it requires only half as much current as the carbon filament, can take a high voltage, and makes good connections, has been found expensive to construct, because of the necessary heating shunt coil, and short-lived, especially if exposed to shocks.

The osmium lamp has the same disadvantage of high initial cost, and also too low a voltage—47 volts. Consequently, with the circuits usually employed these lamps must be used in series groups, or some device for subdividing the voltage must be employed. The latest model has a voltage high enough to permit the lamps to be used in pairs, but this advantage is met by still higher first cost. The consumption of power is 1.5 watts per candle-power, only half that of the carbon filament, which is equal, if not superior, to the osmium lamp in longevity. In comparison with the Nernst lamp, the osmium lamp has the disadvantage that it can be used only in a pendent position, as in any other the osmium filament bends when softened by heat.

The tantalum lamp consumes about as much energy as the osmium lamp, but has the advantage of a longer filament so that it can be used on a 110-volt circuit. It can also be placed in any position. It may be assumed that tantalum lamps will be made for still higher voltages. The useful life is from 400 to 600 hours, and the total life more than 1,000 hours. Except in the very early life of the lamp it must be carefully guarded against shock, for the filament is easily broken and, although the broken ends fuse together when placed in contact, and the lamp continues to burn, the filament is frequently so much shortened by the process that it soon succumbs to the increased demand made upon it. On the other hand, the fact that the specific resistance of tantalum increases with increase of temperature makes the tantalum lamp less sensitive than the carbon filament to variations in voltage. A further, though slight, advantage is that the luminous surface is larger and more uniformly distributed in azimuth than is the case in a lamp with one or two thin filaments. According to Ambler, an increase of 4 per cent in voltage produces an increase of 24 per cent in the light of a carbon filament, but only 9 per cent in that of a tantalum lamp, and the increase of voltage required to cause an equal increase in light is twice as great with the latter as with the former. An increase of 2 per cent in voltage produces 11 per cent increase of light in the carbon filament, but only 5 per cent in the tantalum lamp. These results are explained by the positive temperature coefficient of tantalum and the negative coefficient of carbon, the increased resistance of the former partially compensating the increased voltage which has caused it. The present low cost of construction (2.5 marks, or about 62 cents) of the tantalum lamp and the high voltage for which it is made give it an advantage over the osmium lamp and a great success might be predicted for it had it not been surpassed in economy by the new zirconium and tungsten lamps. The zirconium lamp is said to consume only 1 watt per candle-power and to have an average working life of at least 500 hours. Some of the lamps are made for 110 volts and over. A 40-volt lamp costs 3 marks (75 cents), a 75-volt 3.5 marks (87 cents), a 120-volt 4 marks ($1).

Guelcher's iridium lamp is made only for low tensions, up to 24 volts. It costs 3.5 marks (87 cents), and is said to consume 1 to 1.5 watts per candle-power. No measurements or experiments to determine the life of the lamp have been published.

The latest arrival in the field of metallic filament lamps is the tungsten lamp, which four firms manufacture by as many different processes. The first firm, or group of firms, uses the patents of Just and Hanamann. The makers have in view a normal lamp of 30 or 40 candles at 110 volts, consuming 1.1 watts per candle, and hope to reduce the consumption to 0.8 watt per candle. Tests made at the municipal electrical works of Munich showed from 38.9 to 45.7 candles, and 1.1 watts per candle.

Kuzel's tungsten lamp, tested by its manufacturer, Kremenecky, of Vienna, showed an efficiency of from 1 to 1.25 watts per candle for lamps of from 19 to 32 volts and a useful working life of 1,000 hours, at the end of which the average reduction in candle-power was only 10 or 15 per cent. The filament automatically welds together if broken, as in the tantalum lamp, so that the life of the lamp is very seldom shortened by rupture. Tests of 32-volt and 30-volt Kuzel lamps at the Vienna Technological Museum showed average efficiencies of 1.06 watts and 1.12 watts per candle, longevities of 1,000 and 1,490 hours, and ultimate diminution of luminosity equal respectively to 1.6 per cent and 4.5 per cent of the initial candle-power. The Austrian Board of Supply reports 55-volt lamps giving 31 candles at 1.1 watts per candle at the commencement of an experiment and 28.6 candles at 1.185 watts per candle after burning 917 hours, being a decrease of candle-power amounting to 7.6 per cent in that interval. I have been informed that it is hoped to place 110-volt Kuzel lamps on the market next year.

The 3-ampere Hewitt lamp consumes only from 0.15 to 0.33 watt per candle. This is about equal to the best result yet attained with flaming-arc lamps. In respect to steadiness and constancy of illumination, the mercury vapor lamp has never been surpassed and even considerable variations in voltage have no effect on it. But the chief merit of the mercury lamp is the fact that it needs no regulation or attention and that its luminosity remains almost unchanged. The length of life of a properly treated Hewitt lamp leaves little to be desired. Lamps have remained in good condition after burning more than 7,000 hours. The American price of a 30-inch lamp of 500 or 600 candle-power, with all necessary connections, is $30. The Heræus lamp, made of the very expensive quartz glass which is transparent to ultraviolet light, costs, with its connections, 300 marks ($75), and Schott's 10-inch uviol lamp, with its holder, costs 125 marks ($31). The chief obstacle to the general employment of mercury vapor lamps is the very disagreeable bluish-green color of their light.

The tungsten lamps, also called osmin lamps, made by the Osmium Light Company, of Vienna, have also been tested at the municipal laboratory of Munich and have shown from 54.7 to 55.6 candles and from 1.026 to 1.047 watts per candle at 110 volts. Six lamps tested at the Technological Museum in Vienna consumed 1.03 watts per candle at the beginning and 1.09 watts after burning 1,776 hours. The manufacturers intend to make osmin lamps giving 40, 50, and 60 candles at 105 and 110 volts.

The average life of the osram lamp of the Deutsche Incandescent Gas Light Company is given by the company as more than 1,000 hours, with no mean decrease in luminosity during that period. In a test made by the Imperial Physicotechnical Institute lamps of 32 candle-power actually showed a 2 per cent increase in brightness after burning 500 hours, while lamps of 25

candle-power showed a decrease of less than 1 per cent. The efficiency of the former was 1.12 watts, that of the latter 1.08 watts per candle. The efficiency remained almost unchanged after 1,000 hours' burning.

The Auer Company proposes to furnish osram lamps even for 220-volt circuits, with efficiencies of 1.2 watts per candle for lamps of 40 and 50 candles, and 1 watt per candle for lamps of from 50 to 200 candles. The average life of these lamps, with undiminished luminosity, is said to exceed 1,000 hours.

Whether the new tungsten lamps will fulfill the high hopes placed in them can, of course, be determined only by thorough tests under the conditions of practice. At present all the new metallic filament lamps are yet in the experimental stage. Newspaper reports often mention such lamps for which an efficiency of ½ watt per candle is claimed, but the 1-watt lamp represents so great an advance that the ½-watt lamp is not yet imperatively demanded. It would appear more profitable to give the inventors of the 1 watt lamp time to perfect it.

The necessity of using the new lamps in the inverted vertical position—which, however, is the best position for horizontal illumination—may perhaps be regarded as a defect, yet quite recently the inverted incandescent gas lamp has invaded an extensive field hitherto monopolized by the electric light.

As we have seen, numerous inventors are working on the tungsten lamp, but the fact should be emphasized that in countries which demand proof of novelty as a condition of granting a patent, in Germany and Austria especially, the first application of Just and Hanamann is the only one that has been successful. Consequently it is at present as difficult to decide which of the various processes will obtain valid patents as it is to foresee which process will furnish lamps of practical utility.

The foregoing considerations suggest the question: Which method of illumination will ultimately surpass and supplant the rest? Electricity, gas, petroleum, alcohol, and acetylene are engaged in fierce competition, in which intensity, cost, convenience, etc., play their parts.

It may be taken for granted that none of the existing methods will soon completely supplant the others. The field is large enough for all of them and more.

Only optimists believe that we shall soon have an incandescent electric lamp consuming only ½ watt per candle-power. The effect of such a lamp on the development of electric lighting and electrical industries is at present incalculable. The electric light is now a luxury, but the ½-watt lamp would make it as cheap as the incandescent gas light, even if the present price of electric energy, 0.40 to 0.50 mark [10 to 12½ cents] per kilowatt hour should be maintained. But increased demand would bring increased supply and a reduction of price. The ½-watt lamp would monopolize the entire field of illumination as the electric light in general was once expected to do, and the result would be a development of electrical industries in comparison with which their present condition would seem a very modest beginning. The increased demand for light would lead to further improvement and further cheapening, to the benefit of all classes of the community.

Some observations upon cathode rays have been recently made by a French physicist, P. Villard, in which he brings out several interesting points. It was found by J. J. Thomson that if we deflect the cathode beam of a Crookes tube by the magnet there remains in the place formerly occupied by the beam a set of rays which are not deflected, and are hardly visible. They start from the same points of the cathode as the ordinary cathode rays, but do not cause fluorescence in the glass. This beam is always of a rose color, even if the vacuum has been made with oxygen, in which the ordinary cathode rays are yellow. Examined by the spectroscope, the spectrum is found to be that of hydrogen. The author thought that the particles of the rays have only the power to illuminate hydrogen, and experiments confirmed this point of view. While hardly visible in very dry gas, the rays become very apparent if we add a small amount of water vapor or hydrogen. If the vacuum was made with oxygen in the first place, we observe the singular phenomenon that the cathode beam is a pale golden yellow color characteristic of oxygen, while the non-deflected rays give only the spectrum of hydrogen. Upon contact with glass, the rays cause a feeble yellow light which seems the same as what the Goldstein rays produce. These latter rays have also the property of emitting a rose-colored light in a tube containing oxygen and a trace of water vapor, and it was supposed that the rays in question were, like the Goldstein rays, positively electrified. To show that this is so, the author makes evident the electrification by deviating the rays by a magnetic field or an electric field. Using hydrogen or water vapor makes it easy to carry out the experiment by increasing the visibility of the beam. The deflection always takes place in the direction foreseen for a positive charge of the particles, and the order of magnitude was the same as for the canal rays. Whatever may be the theory as to the formation of the new rays from the cathode, the author's experiments seem to make two points evident, first, that a cathode in activity sends out rays which transport positive charges, second, that in a mixture of oxygen and hydrogen (or water vapor) the cathodic corpuscles cause preferably the luminescence of oxygen, and on the contrary the positive particles only illuminate the hydrogen. This latter phenomenon is of interest in the explanation of the luminescence of gases which are traversed by electrified particles.

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